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ASTRONOMY

THIS *Course covers the whole field of astronomical discovery and knowledge, including recent work on the computation of the sun's distance from the earth, the moon, the planets, comets and meteorites, the stellar system, and the nebulae. It is necessarily associated in some degree with the Course on* PHYSICS, *in Vol. 2.*

33 LESSONS

LESSON 1

The Study of the Heavens

ASTRONOMY is the science concerned with the study of the heavens, of worlds beyond our own, of conditions that exist upon vast rolling spheres, many of them hundreds of times bigger than the earth. It deals with hundreds of millions of suns, with worlds in the making, worlds dead and arid, whirling fragments of worlds—all passing above us from night to night. Myriads of suns are progressing through successive states of stellar evolution, from youth to old age; there through interminable aeons they waste away.

With all these things and more astronomy is concerned. It endeavours to unravel the tangle of mysterious forces which fill space with energy and like a vast invisible mechanism hold together each fractional part, no matter how small, of our universe, notwithstanding the tremendous speed with which each unit is travelling through an infinity of space. Astronomy has been built up through the ages to become one of the most exact of sciences—so exact that numerous celestial events that will not occur until many years hence can be foretold to a minute, sometimes (as with eclipses of the sun) to a second or so.

To the naked eye of an observer on a clear, starlit night some 2,000 objects can be seen bespangling the heavens; a good pair of field glasses will increase the number visible about 100-fold; a powerful telescope will reveal the existence of several thousand where but one is visible to unaided vision. The number increases with each improvement in the powers of the telescope, so while about 30,000 million suns are at present known to enter into the composition of our galaxy, they are actually very much more numerous.

With the exception of the sun, moon, and an occasional comet, meteor, or nebula, all celestial objects appear to the naked eye as points of light. This is because of their enormous distance which, notwithstanding the immensity of the objects, reduces them to an apparent width that is inappreciable to the eye.

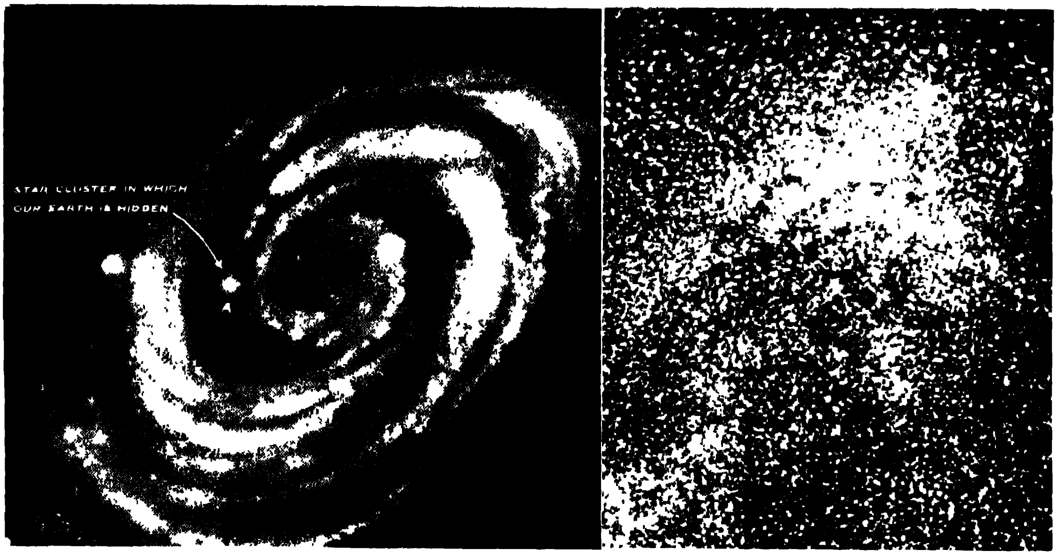
SATURN is nearly 800 million miles distant from the earth. Were it as near as the moon it would present to us the magnificent spectacle depicted in this drawing.

The telescope, and its accessories the spectroscope and interferometer, together with astronomical photography, have enlarged man's vision so greatly that the astronomer is now equipped with the equivalent of an eye 45 feet in diameter. Vastly remote suns can now be measured, and the analysing "eye" of the spectroscope reveals much about them. With such instruments at his disposal the astronomer experiences no difficulty in accurately distinguishing between suns and worlds; although both shine and appear to the naked eye as stars, only the suns, like colossal furnaces, shine by their own light. Worlds shine by reflected light from the suns round which they revolve. They are always very much smaller spheres, more or less resembling the earth. Known worlds are usually very much nearer to us than the suns.

Planets and Satellites

With those worlds which revolve round the sun astronomers are much better acquainted, knowledge being derived from direct observation, mathematical deduction, and inference based on theoretical considerations of known analogies. The worlds that revolve round the sun are divided into planets and satellites, the latter being worlds that revolve round some of the planets. None of the satellites is visible to the naked eye except the earth's satellite, the moon. Good field glasses will reveal four of Jupiter's satellites; a comparatively large astronomical telescope must be used to see more. So many celestial objects are only just beyond naked-eye visibility that an ordinary telescope will help in identifying them.

Were many of these "points of light," as they appear to unaided vision, only as near to us as the moon, spectacles of unexampled grandeur would be presented. Saturn, for instance, a world 736 times the size of the earth, would appear at times as shown in the illustration if it were only 238,860 miles away, which is the average distance of the moon. In large areas of sky the stars are so far away that only a dim



THE MILKY WAY. As seen by the naked eye, the Milky Way appears as a luminous belt of faint light stretching across the sky at night. Could this belt with its curious structure be viewed from outer space, it would be seen to be composed of streams of innumerable stars, condensed clusters and star-clouds, the whole arranged in the form of a revolving spiral. In one of the clusters our solar system is considered to be situated, as indicated at A. On the right is a small portion of the Milky Way as revealed by photography through a powerful telescope.

light is seen with the naked eye. Such a region is the great belt constituting the Milky Way ; the illustration on the right, above, shows a small portion as revealed by photography through a powerful telescope. Every dot there represents one of the two thousand million suns known to astronomers. The space beyond seems hidden by their numbers, yet the individual suns are relatively as far apart from one another as our sun is distant from the nearest stars or suns in our region. Beyond them again are vast galactic systems.

On any cloudless and moonless night one can see between 1,500 and 2,000 points of light collectively known as stars, spread over what appears to be a great dome or hemisphere. The ancient astronomers originally regarded the latter as solid—hence its name, firmament. It is now known to be illimitable space extending to unfathomed depths, the stars being, with few exceptions, suns at various and immense distances. They all appear to the naked eye to be still, and to remain in the same relative position to one another from night to night, and they are called fixed stars. They are not actually fixed, but the term is still used to distinguish them from the planets.

The planets may be regarded as worlds ; they shine by the reflected light from our sun, and are very much nearer to us than any of the other stars, which are suns far more distant than our own. Only five planets are ordinarily visible to the naked eye, i.e. without optical aid, though two more that are very faint can be seen if their position is known, and more still with an astronomical telescope.

The student should soon be able to distinguish the planets or worlds from the stars or suns by their movements. The four planets Venus, Jupiter, Mars, and Saturn are the most readily identified by their brilliance ; the first three appear to be brighter than any of the other stars. Other aids to identification are their steady, continuous light and the comparative absence of the scintillation, or twinkling, so characteristic of the starry suns.

Star Groupings

The largest number of stars that can be observed by the naked eye on the clearest night is about 2,000. This represents the number visible at one time, when we see only the hemisphere or one-half of the entire heavens. The other half reveals approximately another 2,000 stars. In the British Isles most of these may be seen in the following circumstances. If the student faces south at, say, 8 o'clock in the evening, and takes note of the positions of many of the more prominent stars, which are arranged in easily remembered geometrical patterns, and then again looks for those same stars about midnight, it will be observed that the whole concourse of stars has moved from east to west to the extent of about one-third of the whole expanse. This will vary according to the altitude of the star, being greatest for those farther south.

Those stars that were near the eastern horizon will by midnight be high up and approaching due south, while those that were in the south will be seen to be descending to the west, and in the course of another four hours will have vanished below the horizon. Thus the whole celestial sphere will appear to be revolving from east to west, with the result that, if the student takes note of all the stars that are visible to the east, south, and west of him at 6 o'clock on a winter's evening, and compares them with all those that occupy the same sections of sky at 6 o'clock on a winter's morning, he will see that they are totally different.

Fresh groupings will have taken the place of those present in the evening sky, while those that were in the north-west portion of the sky will have changed places with those that were in the north-east portion. The star-maps in pages 1735 and 1736 present a picture of the chief stars to be seen on each occasion in January.

Circumpolar Stars

There are approximately another 1,000 stars which remain for ever out of sight of the observer in Britain and can be observed only by travelling to a place south of the equator. All the stars that pass near the zenith or overhead point, however, together with all those to the north of it, are always visible on any fine night ; it is only their position relative to the northern horizon that changes. The stars within this region are said to be *circumpolar*.

The heavens as revealed to the naked eye were all that was known to the astronomers of Chaldea and Egypt of 5,000 years ago. This is why the constellations, particularly those of the zodiac, i.e. the twelve constellations through which the sun appears to pass in the course of a year, constitute the basis of the most ancient astronomy. The chief constellations consist mostly of conventional star groupings associated with imaginary figures of mythological beings, both animal and human. In ancient times they had an impressive symbolical meaning, and represented some deity or annual event concerned with the sun god or moon god. Thus it was that astronomy was intimately connected with the religions of most ancient peoples. So it has continued to the present day. Easter, for instance, is fixed by the occurrence of the first full moon after March 21.

Myth and Mysticism

Not until the time of the Greeks did astronomy begin to emerge from the realm of myth and mysticism, though for long the earth was still regarded as an enormous flat disk encircled by an ocean that lost itself in mystery just as did the sky above. The solid firmament conception gradually gave way to scientific reasoning. The ideas of Empedocles (450 B.C.) and Plato (427–347 B.C.) led to the belief that the earth might be a sphere in space. Pythagoras in the 6th century B.C. has been credited with a similar idea in connexion with his famous theory of the "harmony of the spheres."

In the time of Aristarchus of Samos (310–230 B.C.) a true conception of the earth's place in the heavens was first evolved. From Aristarchus' one surviving work it appears that he held the opinion that the earth was a sphere in motion round the sun. Succeeding ages would not accept his scientific reasoning, and for eighteen hundred years mankind clung to the erroneous idea that the earth was the centre and all-important pivot of the universe, around which everything else revolved.

LESSON 2

Ancient Astronomy, and Pioneers of the New

HIPPARCHUS, the greatest astronomer of antiquity, who flourished in Rhodes in the second century B.C., adhered to the idea of a fixed earth, although by prolonged observation he decided that sun and moon moved at varying speeds, and that at certain times the latter was nearer the earth than at other times. As the result of his discoveries, astronomers were enabled to predict when eclipses of the sun would take place—a matter of considerable moment in those days, when eclipses were viewed with apprehension as presages of dire misfortune.

The astronomy of the ancients was consolidated by Claudius Ptolemaeus, or Ptolemy as he is commonly called, about A.D. 150, in his book called the *Almagest*. For 1,400 years the *Almagest* was the textbook of astronomy, and the system described therein goes under the name of the Ptolemaic, although Ptolemy was a compiler rather than an original thinker and observer. The Ptolemaic conception of the universe is shown in page 1685 ; the earth is fixed in the centre, the other heavenly bodies moving around it in circular orbits.

The sun, moon, and planets were supposed to be each attached to rotating crystal spheres, which in turn, together with the earth, were contained within an immensely larger sphere to whose inner surface were fixed the outermost stars. The eccentric motions of the planets (Gr. *planetes*, wanderer) were accounted for by

supposing them to move in small circles whose centres themselves revolved about the earth. This epicyclic motion is explained in the diagram below.

Copernicus and Brahe

This ingenious and complicated system became somewhat modified in the course of centuries, as observation revealed its inaccuracies and inadequacy. As early as 1440 Nicolas of Cusa, a cardinal of the Church, wrote: "I have long considered that the earth is not fixed, but moves as do the other stars"; and in 1543

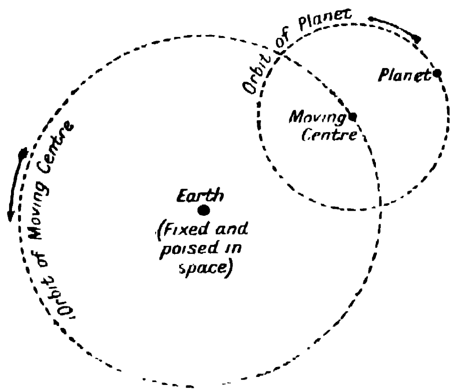


DIAGRAM OF EPICYCLIC MOTION. According to this theory, planets revolve round a point which itself revolves round the earth.

Nicolaus Copernicus published his great work, *De Revolutionibus Orbium Coelestium* (Concerning the Revolutions of Celestial Spheres), in which he demonstrated that the sun is the central body in our universe, and that round it revolve the earth and the other planets.

Tycho Brahe (1546 1601) refused to accept the Copernican theory. He had made very exact measurements of the motions of the sun, moon, and planets; his instruments were far more accurate than any used before, and he considered that if the Copernican system was correct, the wide arc produced by the earth's motion round the sun should have made the apparent places of the stars change annually, whereas they did not appear to do so. It has been learned since that their positions do change, but so slightly, owing to their distance, that a telescope is needed to reveal the shift.

So much in the Copernican theory was incontestable that Tycho Brahe devised a theory which still left the earth as the all-important centre of the universe, while the sun, which he regarded as at a very great distance, revolved round the earth. The moon did likewise. The planets he considered to revolve round the sun. This was the Tychonic system, intermediate between the Ptolemaic and Copernican systems. It was not generally accepted, but Brahe's numerous accurate measurements and observations led directly to the discovery of the fundamental laws of the universe, and of the reason why the planets travel as they do with varying speeds round the sun.

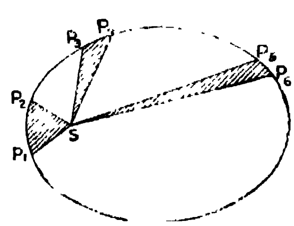
Kepler and Galileo

This discovery was due to the genius of a pupil of Tycho Brahe, John Kepler (1571–1630), who undertook to calculate from those observations how the planets ought to move round the sun in order at all times to appear in the positions they do from the earth. The laws of Kepler are three in number:

1. The orbit of each planet is an ellipse having the sun in one of the foci
2. As a planet moves round the sun, the areas (P_1P_2S, P_3P_4S, etc., shown in the accompanying diagram) described by its radius vector, i.e. the space enclosed between lines drawn from the focus (S) to two successive points (P_1, P_2, etc.) in the planet's path, are proportional to the time taken in describing them; or, to put it in other words, its radius vector sweeps over equal areas in equal times
3. The square of the time in which each planet completes its orbit is proportional to the cube of its mean distance from the sun.

This third law shows that there is a definite numerical relation between the motions of all the planets, and that the time which each of them takes to complete its orbit depends upon its distance from the sun. Why the planets should obey these so-called laws was not known, owing to the fact that the force of gravitation had not then been discovered, but these laws propounded by Kepler enabled astronomers to predict where a planet would be at a stated time.

About the same time Galileo Galilei (1564 1642), a native of Pisa, heard that a Dutch instrument-maker had discovered the principle of the telescope for magnifying objects, an elaboration of the magnifying glass invented by Roger Bacon (*c.* 1214 94). Galileo conceived the idea of applying the principle to magnifying the stars. By experimenting with a convex lens and a concave lens fitted into a tube, he succeeded, in 1609, in constructing the first astronomical telescope. It magnified only three times, so he ground and polished other lenses and made a telescope magnifying eight times.



KEPLER'S SECOND LAW

The planets were then found to be perceptibly different from the stars, and instead of points of light, tiny disks were revealed. Then Galileo constructed a telescope that magnified 30 times. He turned it on Jupiter on Jan. 7, 1610, and saw, instead of a point of light, a world with a disk almost as

large as the moon appears to the naked eye. This was expected from his preceding observations, but there on the left side were two brilliant points of light and another on the right. A few days later a fourth appeared, and from evening to evening they changed places around the large disk of Jupiter. Galileo called them the Medicean stars. Later it was realized that they were moons, and Jupiter is now known to have eight other, though much smaller, moons: the first four are called the Galilean moons.

When Venus was first observed by Galileo, in September 1610, it appeared like a half-moon, and then during succeeding weeks it gradually changed into a crescent. Thus it was seen that Venus exhibited phases similar to the moon, a fact which confirmed the Copernican theory. Since this claimed that Venus revolved round the sun in an orbit within that of the earth, Venus would gradually come between the earth and the sun, and so exhibit phases.

So far the glimpses at other worlds had been what might have been theoretically expected, but when Saturn was observed in 1610 it presented an unexplainable state of things. Through the imperfections of those early lenses, Saturn appeared to be a disk similar to Jupiter but accompanied by two lesser disks, one on each side. During 1611 the lesser disks became smaller, and in 1612 they vanished altogether, but without revolving round Saturn. This appeared to conflict with the Copernican theory. Then after a year or two the disks both reappeared, and began to grow, until they finally, after a few years, appeared like two handles.

The planet was studied for nearly half a century, and through better telescopes, before Christian Huygens (1629–95), a Dutch astronomer and physicist, thought out the true explanation in 1655. This was that Saturn was surrounded by a thin flat ring separated from the body of the planet by intervening space. Thus was another objection to the Copernican theory swept away. Mars and Mercury, together with Venus and Jupiter, had been found to substantiate it further.

LESSON 3

Mathematics of the Universe

Kepler had shown how the planets moved according to the three laws, but what made them do so was a problem. Descartes (1596–1650), a French philosopher, propounded his theory of ethereal vortices to account for it, and this was generally accepted by thinkers. Then the idea arose that it might be gravity, or the weight of the planets falling toward the sun similar to the way in which propelled bodies fall toward the ground.

Galileo had discovered, long before, the first law of motion, that a body will continue to move always in a straight line unless it is deflected by some external force. A body propelled from the ground always returned to it after travelling in a tangent—a thrown ball, for instance. It was supposed that some force at the centre of the earth caused this, for the law of gravitation had not yet been discovered.

Universal Gravitation

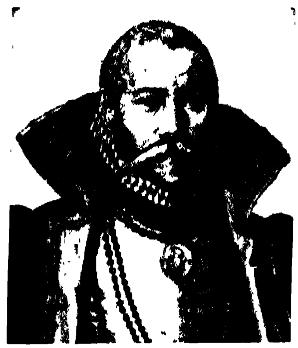
It could be mathematically shown that if only the ball could be propelled fast enough it would remain suspended and continue travelling round the earth, provided that it met no air or other hindrance. Huygens, in 1671, propounded the laws which govern a body travelling in a circle, showing that it was subject to a force similar to gravity. Robert Hooke (1635–1703) had already conceived the true idea of universal gravitation, but from lack of mathematical ability he was unable to frame a law to prove it. Other astronomers and mathematicians had similar ideas. Chief among them were Sir Christopher Wren (1632–1723), Edmund Halley (1656–1742), and Sir Isaac Newton (1642–1727).

It had already been learned that it was possible to account for the orbital motion of our world and the planets by supposing them to be subject to a force which attracted them to the centre of the sun, just as it was known that the earth attracted bodies to its centre as if a gigantic lodestone were there. This pulling to earth which gave bodies their weight was known as gravity; thus gravitation as an *idea* was not discovered by Newton.

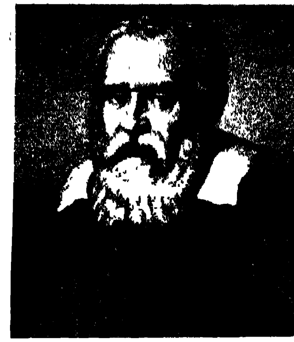
Newton's Calculations

The idea needed defining mathematically, so that it could be proved experimentally in any test case. Newton set himself to do this in 1665. He knew the rate at which a body will fall to the ground at the earth's surface, and he decided to find out the rate at which the moon should fall toward the earth if the same force, that is, gravity, was deflecting it. It was most important that the distance of the moon should be known accurately. Newton based his calculations upon the accepted distance of 30 times the earth's diameter. Thus far it was correct, but unfortunately the earth's diameter was considered to be 6,900 miles instead of 7,927, an error which threw all Newton's calculations out, and he concluded that the moon was not pulled by gravity toward the earth.

COPERNICUS



TYCHO BRAHE



GALILEO

FAMOUS ASTRONOMERS. Copernicus (1473–1543) proved that the sun, and not the earth, was the centre round which the other planets revolved. Tycho Brahe (1546–1601) by his accurate calculations paved the way for Kepler (1571–1630) and Galileo (1564–1642).

JOHANN KEPLER

SIR ISAAC NEWTON

JOHN FLAMSTEED

Kepler was the first to discover that a planet's orbit is elliptical. Galileo established the Copernican theory and, like Kepler, enunciated the principles on which Newton (1642–1727) based his exposition of the laws of gravity. Flamsteed (1646–1719), first Astronomer Royal, catalogued the fixed stars.

EDMUND HALLEY

MARQUIS DE LAPLACE

SIR JOHN HERSCHEL

Halley (1656–1742), Flamsteed's successor, observed the comet that bears his name and predicted the date of its return. Laplace (1749–1827) was the greatest mathematician of his time. Herschel (1792–1871) did brilliant work in mapping the heavens; his father and aunt were also notable astronomers.

He abandoned the problem for 16 years. Then, becoming aware that Picard, a French astronomer, had in 1679 found that the earth's diameter was nearly 8,000 miles, Newton recomputed his former figures and discovered that after all the moon did fall towards the earth as if subject to the force of gravity. Then he arrived at the fundamental law that holds the universe together, that "every particle of matter in the universe attracts every other particle with a force varying inversely as the square of the distance between them, and directly as the product of their masses."

The Moon's Velocity

To understand how, in accordance with the foregoing law, the moon continues to fall towards, and yet never reaches, the earth, the student must remember that the earth is a sphere and the moon distant from it on an average 238,860 miles While a body will fall to the earth at the rate of about $16\frac{1}{10}$ feet in a second when near the earth's surface, it will fall at the rate of only $\frac{16}{3600}$ of a foot at the distance of the moon, because the moon is 60 times farther away from the earth's centre than is the earth's surface, and is therefore attracted 3,600 times less strongly. In one second the moon covers 3,350 ft. of its orbit It is easy to calculate that at the moon's distance a deviation towards the earth of $\frac{16}{3600}$ of a foot in every 3,350 ft. is just sufficient to convert straight-line motion into circular motion. Thus the moon's velocity is so nicely balanced to the earth's gravitational pull that, apart from minor variations due to other gravitational pulls and subject to the laws of Kepler, it never reaches the earth but perpetually encircles it

Tangential Fall of Celestial Bodies

The student may thus learn, as Newton did, that the force which keeps the moon always falling to the earth also keeps the planets always falling toward the sun in the same manner. It must, however, be remembered that the fall takes the form of a tangential curve which is a compound of the body's initial velocity and the gravitational pull from the centre of attraction, with the result that the body moves in a closed orbit.

The story that it was the fall of an apple which resulted in Newton's discovery of the law of gravitation may be true, but it is improbable, because the apple's perpendicular fall was totally different from the tangential fall of celestial bodies: moreover, the cause of the apple's fall was regarded as already satisfactorily explained by gravity from the earth's centre.

The question was not whether the earth's gravity attracted terrestrial things, but whether gravitation caused celestial bodies to travel as they are observed to do. Newton discovered the law concerning the latter, and it was incorporated with other discoveries in his great work, *Philosophiae Naturalis Principia Mathematica*. This, generally called the *Principia*, was printed and published at the expense of Halley in 1686 87.

Exact Movements

The book has provided the basis for all calculations of the movements, not only of the planets, satellites, and other bodies of the solar system, but also of the distant stars and remote clusters far beyond our sun, where the same laws operate. So exact are their movements in accord with Newton's laws that ever since it has been possible to foretell, by means of a few observations, the positions of the celestial bodies at different times far ahead. Thus the tables of the sun, moon, and planets are prepared years in advance for the *Nautical Almanac*, at the Greenwich Observatory. This tells the navigator exactly where the sun, moon, and planets are to be found at a certain time, this information enabling him to determine his position at sea.

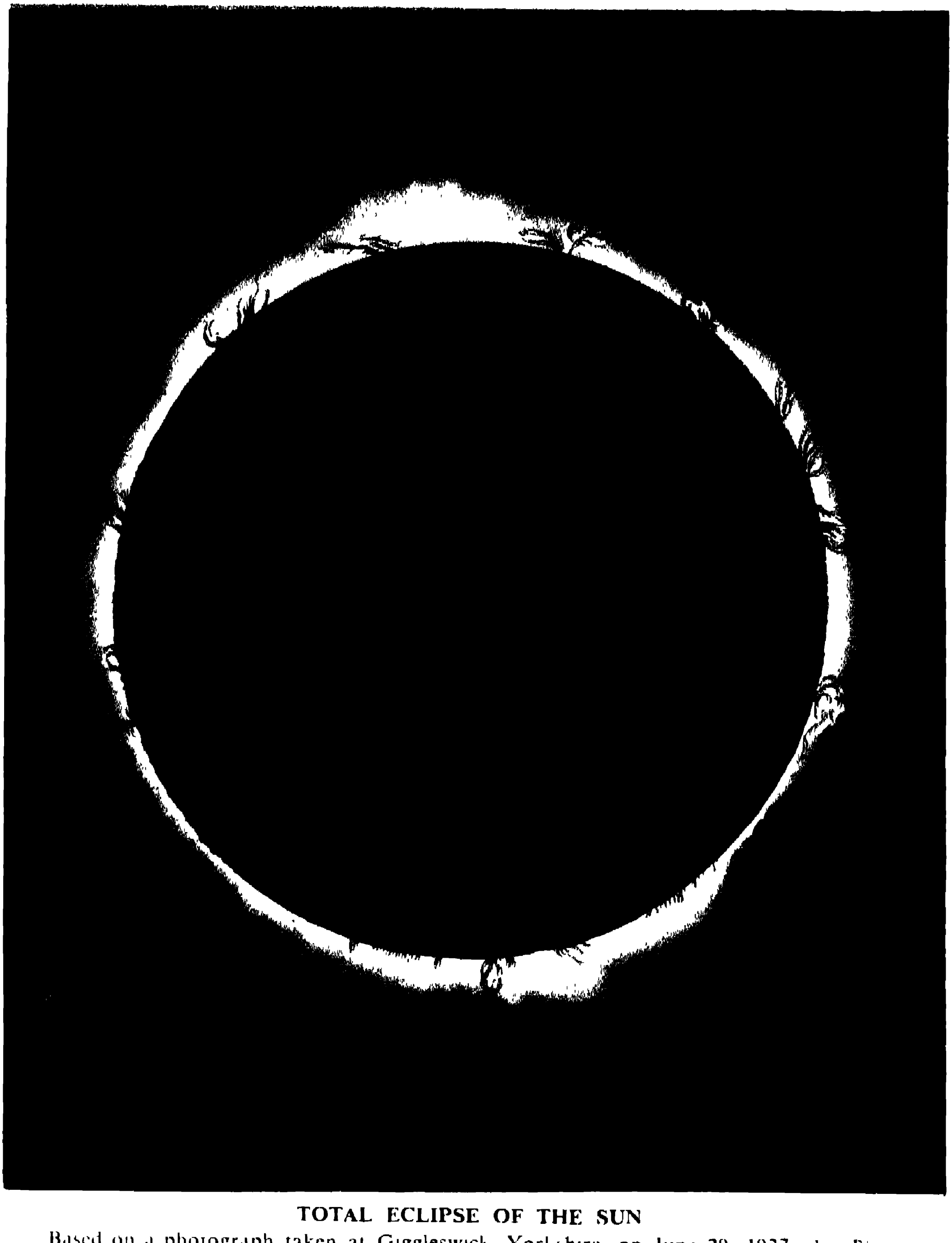
The improved mathematics of the 20th century accounted for some unexplained discrepancies revealed in matters unknown in Newton's day and to be perceived only by the extreme accuracy of present-day observation. They are too small, however, to affect ordinary mathematical calculations appreciably. They have been accounted for in Einstein's theories of relativity.

LESSON 4

What is Known about the Sun

By far the most important member of the solar system is the sun, not only on account of its immensity and enormous mass, with its resultant gravitational pull which keeps all the planets in their paths, but also because no life would be possible on earth without its continuous light and heat.

As seen by the naked eye, the sun appears as a flat disk, but through an astronomical telescope fitted with a sun prism, it is seen to be an immense globe. So immense is this globe that were it hollow, it could enclose the material of 1,300,000 bodies the size of the earth. So huge is it that were the earth at its centre, the sun's surface would be nearly 430,000 miles above us, and since the average



TOTAL ECLIPSE OF THE SUN

Based on a photograph taken at Giggleswick Yorkshire, on June 29, 1927 this Plate displays the inner corona and the solar prominences Only a total eclipse allows these immense tongues of vivid flame to be directly photographed One of them viewed through the spectroscope, is seen on the other side of this Plate

Courtesy of the Astronomer Royal Greenwich Observatory

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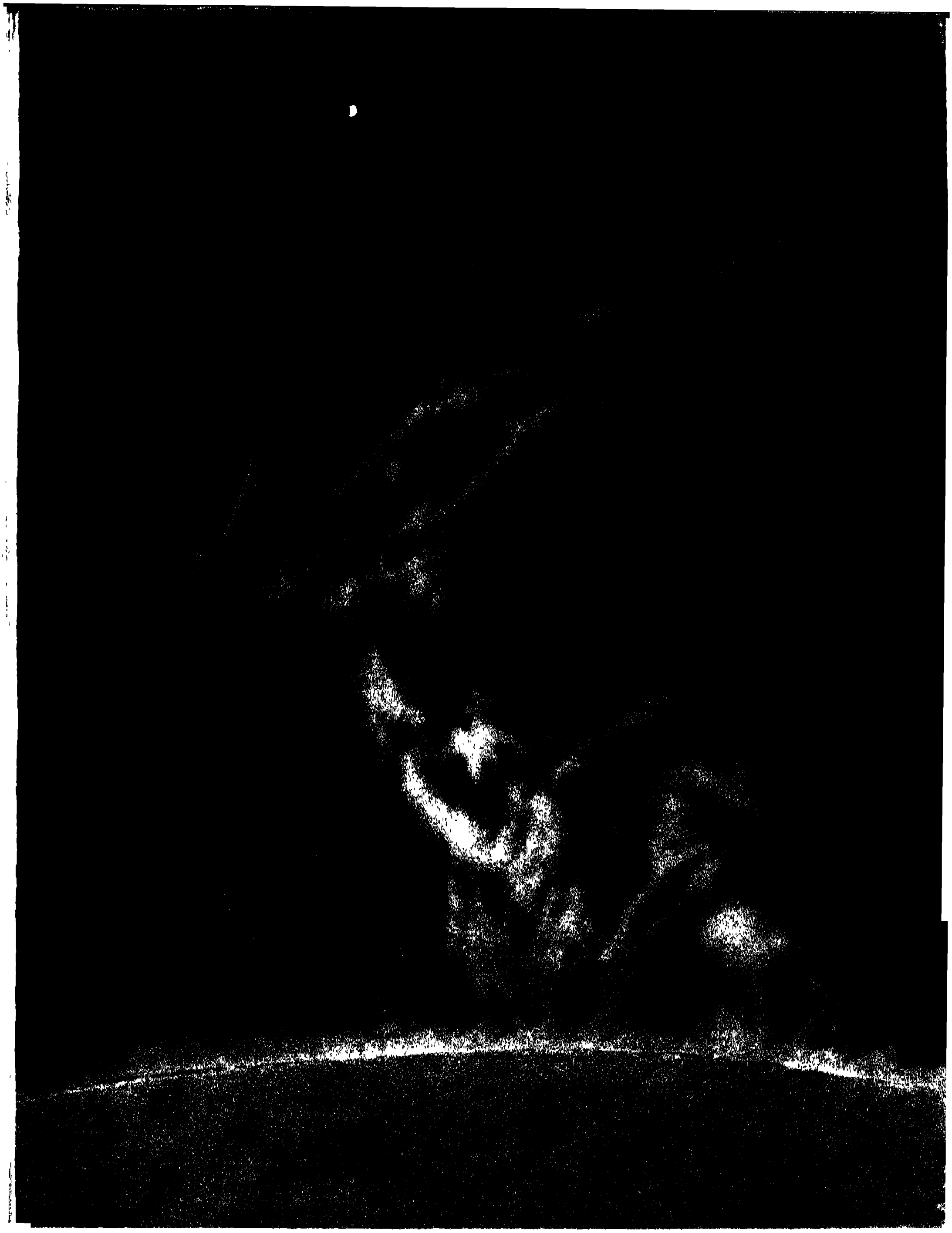


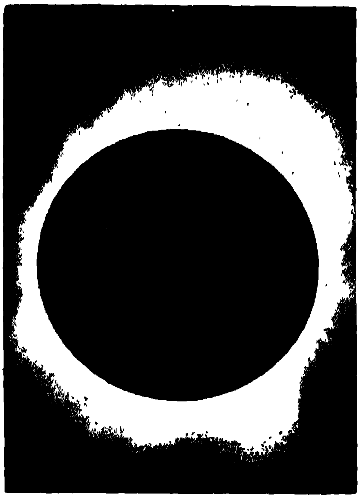
SOLAR PROMINENCE

The sun's violent outpourings of luminous gases (prominences) is well seen in this calcium prominence, 140,000 miles high, taken from a photograph through the spectroscope at two positions in the violet region. The small green sphere represents the earth on the same scale. *See also* preceding Plate

Mount Wilson Observatory

distance of the moon is 238,860 miles from the earth, it follows that the moon would revolve far down within the sun.

The sun's diameter is about 864,000 miles. If this were represented by a globe a foot in diameter, the earth would, by comparison, be represented by a tiny sphere less than an eighth of an inch in diameter; by placing this nearly 108 feet away from the globe representing the sun, we should then have the proportionate distance of the earth from the sun. This amounts to an average of 93,005,000 miles, which is usually described as the mean distance, for because the distance of the earth from the sun is continually changing from day to day between two extremes, the average, or mean, is stated for purposes of comparison.



CORONA. The magnificent spectacle afforded by the corona which surrounds the sun, as it appeared in the total solar eclipse of May 28, 1900.

This applies to all other celestial bodies, unless the maximum and minimum are given. These distances are given as from the centre of the sun to the centre of the earth. Celestial distances are always given from centre to centre of spheres. This figure of 93,005,000 miles, the most accurate yet obtained, having a possible uncertainty either way of only 9,000 miles, was determined by 1942 by Sir H. Spencer Jones (British Astronomer Royal 1933–55) from data based on the co-operative work of 24 observatories all over the world in 1931, the year in which the tiny asteroid Eros achieved its latest near approach to the earth.

Sun's Rotation

That the sun rotates on its own axis is not obvious to the eye, but observed telescopically it is seen that striking details on its surface travel across its disk from east to west. Exact measurements have shown that different parts of the sun's surface travel at different rates and that the rotation period varies according to latitude. At the sun's equator it amounts to 25 days 1 hour. At latitude 30 degrees north or south the rate of the sun's rotation is about 26 days 6 hours. In latitude 40 degrees it averages about 27 days 12 hours, nearly 31 days for latitude 60 degrees, and about 34 days in polar regions.

The sun's surface is called the photosphere, or sphere of light, and it consists of incandescent clouds floating in a less luminous but fiery atmosphere. It is intensely brilliant, owing to the very high temperature, between 5,500 and 6,000 degrees Centigrade, the most brilliant electric light appears black by comparison when projected against the sun's photosphere. Observed through a powerful telescope this is seen to be covered with still more intensely bright patches resembling luminous granules, which are usually about 500 miles in length. They are in places assembled together in long streaks called filaments and resembling willow leaves; actually they are incandescent cloud formations produced by metals in a state of vapour, changing rapidly in shape and position.

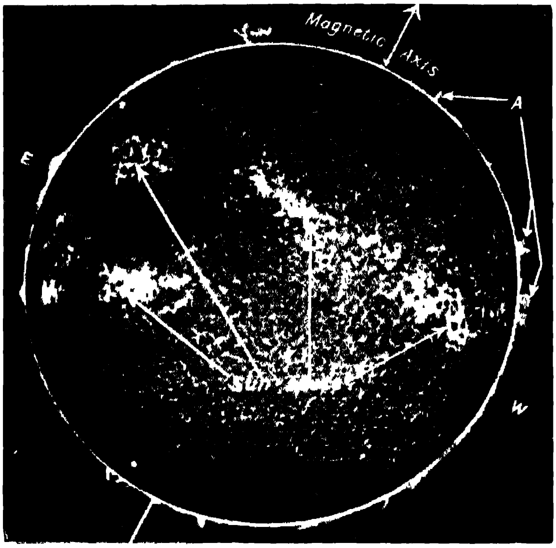
Sun Spots

The sun's surface is mottled with very bright streaks and patches called *faculae*: they are less apparent toward the centre of the disk, but very much in evidence around what are known as sun spots. These are storm centres and cyclones of incandescent vapours. They vary greatly in diameter, from less than 500 miles to occasionally 50,000 miles; the whole earth could be lost in one of these storm areas. They appear and sometimes disappear in a few days; others persist for months—on one occasion, in 1840–41, for 18 months. It is partly by these persistent sun spots that the sun's rotation in various latitudes has been accurately measured.

Terrific Cyclones

In appearance a sun spot consists of a relatively dark central part, called the nucleus, surrounded by a border relatively less dark, though these apparently dark areas are still brighter than almost any illuminant that can be produced on earth. The sun has to be artificially darkened both for observation and for photography. The shaded area surrounding a group of spots, which is the disturbed storm area, is sometimes as much as 150,000 miles across.

These spots can be seen to develop by a gathering of brilliant faculae; then small dark spots appear; these develop and coalesce, and the brilliant granules become changed into filaments and converge inwards towards the centre, taking on a more or less rotary movement. This is the cyclonic motion, which is usually concentrated in two main spots, one called the leader, the other the follower. Speeds of a thousand miles an hour are often witnessed, the changes being considerable even in half an hour, and these terrific cyclones sometimes persist for weeks.



SUN SPOTS AND A TOTAL ECLIPSE. Spectroscopic photograph taken at a time of maximum sun-spot activity. The light patches which surround the apparently dark sun-spot vortices are violently disturbed eruptive areas of cyclonic activity. These break through the clouds of glowing calcium vapour which covers the sun beneath the enveloping helium and hydrogen. Note the solar prominences (A) erupted from the chromosphere. Note, too, that the solar east and west, seen through the telescope, are reversed.

Sun spots show that the sun has a stormy period followed by a quiescent one. It was discovered by Schwabe of Dessau in 1843 that the numbers of spots periodically increased and then decreased over a period of between 11 and 12 years from maximum to maximum. At the time of writing, the last minimum occurred in 1954, and a maximum is expected in 1958. Usually maxima occur four years after a minima, the other seven years of the whole cycle being occupied by a decline slower than the rise. At minimum, all spots may vanish for weeks or longer. When they reappear, these solar storms begin in high latitudes, and in the course of the next three or four years they increase towards the equator, and at the time of maximum as many as a hundred may be seen stretching across the equatorial belt of the sun.

The Chromosphere

Above the photosphere of the sun is another atmosphere, called the chromosphere, which is composed mainly of flaming calcium, hydrogen, and helium vapour, extending above the photosphere to a height of between 10,000 and 12,000 miles and in eruptive outbursts for hundreds of thousands of miles. This is the region of scarlet light, hence its name chromosphere, or sphere of colour. Hydrogen predominates in the higher levels of this fiery atmosphere. The lower portion is called the reversing layer, because, when at the moment of totality during an eclipse of the sun a spectroscope is analysing its light, a transformation takes place.

All the dark lines which normally are in the solar spectrum suddenly flash out in brilliant colour against the dark background which has replaced the normal spectrum band. This reversing layer is a region of denser atmosphere than the chromosphere, extending probably not more than 500 miles above the photosphere. The spectral lines show it to be composed of the vapours of numerous elements.

Among the important elements discovered in the sun are silver, tin, lead, sodium, potassium, silicon, zinc, magnesium, iron, aluminium, nickel, oxygen, titanium, manganese, chromium, cobalt, zirconium, vanadium, cerium, neodymium, lanthanum, scandium, carbon, yttrium, strontium, barium, gallium, lithium, copper, and others, including the calcium, helium and hydrogen present in the higher atmospheric layers. Over 67 elements are known to be present in the sun.

ises

Much may be discovered during an eclipse, when the moon's dark body is interposed between earth and sun, so that a greater or lesser portion of the latter is hidden from our world.

If the earth, sun, and moon moved in the same plane, there would be a solar eclipse once a month, at each new moon. But the moon moves in an orbit inclined at an angle of a little more than five degrees to the plane of the earth's path, or the ecliptic as it is called, and so there can be an eclipse only when the three bodies are approximately in a straight line at the moment when the moon crosses the plane of the ecliptic. The points where the moon crosses the ecliptic are called nodes, and there is an eclipse of the sun each time the new moon happens to be at one of these nodes.

Partial eclipses take place when the new moon is not quite at the node. Annular eclipses are observed when the moon is too far from the earth to hide the sun completely. (The distance of the moon from the earth varies from 221,463 miles to 252,710 miles.)

Total eclipses of the sun are eagerly looked forward to by astronomers, but unfortunately they are of short duration, lasting only from one second up to 7⅝ minutes. In the latter case the shadow band cast by the moon covers a belt 167 miles wide and sweeps across the earth from west to east with great rapidity. Total eclipse is visible only from places swept by the shadow, but beyond the belt, for a distance reaching to as much as 2,000 miles, the sun is seen in a state of partial eclipse.

There must be at least two solar eclipses in a year. There may be five. Total eclipses are much rarer for any given place than partial eclipses. The last observable in London was in 1715 ; the next visible from London will not take place until June 4, 2151. England was in the shadow zone of a total eclipse on June 29, 1927, and will be so again on August 11, 1999, when in Devon and Cornwall the shadow will last for two minutes. On June 30, 1954, a few seconds of totality were observed in the northern Shetland Islands.

Discovery of Helium

On the short occasions when the sun has been completely eclipsed some remarkable scientific discoveries have been made. The corona and prominences which puzzled the observers of the 1706 and 1715 eclipses were proved by the Spanish eclipse of 1860 to be definitely solar. During the total eclipse of 1868 the spectroscope was applied to the prominences, with the result that these were proved to consist of glowing gases, one of which was hydrogen ; and a bright yellow line in their spectrum was found by Sir Norman Lockyer (1836–1920) to belong to a different element, to which the name helium was given. It was not until 1894 that this element was found by Sir William Ramsay (1852–1916) to exist also on the earth. The eclipse of May 29, 1919, provided an opportunity for testing Einstein's prediction, based wholly on theoretical reasoning, that light is subjected to deflection by gravity. Two parties of observers left England, one going to North Brazil and one to Principe Island off the African coast, and in both cases the observations tended to confirm the Einstein theory.

The Corona

During a total eclipse the solar prominences —great tongues of vivid flame rising sometimes to a height of 400,000 miles above the sun's surface, with a velocity of 250 miles a second—can be clearly observed. The corona appears then most clearly as a halo of light extending into outer space for two or three times the diameter of the sun. Through the spectroscope it is revealed as consisting of glowing gas of an extreme tenuosity, now known to be the vapours of iron, nickel, and calcium at a temperature of about a million degrees.

Sun-spot phenomena are often accompanied by and followed by electrical disturbances and violent magnetic storms on earth, due apparently to electro-magnetic radiations and corpuscular particles from the sun-spot regions. A 27-day recurrence of magnetic disturbances has been frequently noted, corresponding to the time taken by the sun in its rotation. It has also

WHEN THE MOON BLOTS OUT THE SUN. **This diagram represents the solar eclipse of January 24, 1925. It will be seen that the track of the shadow of solar eclipse, extending from western Canada to the north of the British Isles, is very narrow compared with the oval area embraced by the partial eclipse.**

been observed that magnetic storms increase and decrease in correspondence with the 11-year cycle of sun spots.

Light and heat are the most obvious forms of solar energy, without which the earth would be a sterile globe with a temperature approaching absolute zero a globe on which not only water but even the air would be frozen solid. The quantity of heat which the earth receives from the sun in a year is sufficient to melt a sheet of ice 200 feet thick over its whole surface. Every square foot receives annually enough energy from the sun to raise a weight of 100 tons to the height of a mile.

Source of the Sun's Energy

The source of this energy was for long a puzzle. It cannot come from ordinary combustion, as in a furnace ; if the sun were entirely composed of the most concentrated fuel, together with enough oxygen to burn it, it could not have shone at its present rate through human history. Even the energy derived from contraction, as the gases in a primitive diffuse sun fell in towards the centre and converted their motion to heat, would not last for more than 50 million years ; whereas geological evidence shows that the sun has been shining for much longer than that.

Loss of Mass

It is now known that at the high temperature of 35 million degrees Fahrenheit in the sun's interior, hydrogen atoms collide with such violence that they break up into their constituent particles. These can then reunite, in a process not discovered until 1939, into helium nuclei, with a small loss of mass. This small mass is, according to the theory of relativity, equivalent to a great release of energy. That this process of fusion of hydrogen into helium can indeed produce large quantities of heat has been impressively demonstrated in the hydrogen bomb. The loss of mass, though it must amount to over four million tons every second, is relatively so small that the sun can afford it for thousands of millions of years into the future, shining steadily at its present rate.

LESSON 5

Finding the Sun's Distance

ALL celestial distances are based upon one measured standard called the astronomical unit. This consists of the distance of the sun from the earth, the sun being the most important star for us and the earth the most important world to us ; their distance apart has been made the all-important " foot-rule," so to speak, of astronomical measurements.

Once the distance of the sun is known, it becomes possible to determine not only the distances in miles of many other celestial objects but also their relative sizes. Their size or volume follows owing to the fact that the *absolute magnitude* of a body is arrived at, by calculation, from its observed *apparent magnitude* at a certain distance. This distance, if known, plus certain other considerations involved in the body's appearance, permits calculation of its absolute or real magnitude, with a very close approximation to the actual size, even of remote stars. The veracity of the method has been proved in certain instances by interferometer measurements.

It will be realized how essential it is that the accuracy of the sun's distance be known, for an accurate conception of the magnitude of the whole heavens depends upon it. For centuries astronomers have endeavoured to measure, by various means, the space between earth and sun. It was evident from the first that trigonometry and geometrical methods offered the best prospect of a solution. But the earth provides a base line of not more than 7,927 miles. This is not sufficient to reveal with any degree of accuracy the sun's parallax, or apparent shift in the sky, when viewed simultaneously from opposite sides of the earth.

Transits of Venus

The astronomer Halley (1656-1742) pointed out in 1716 the possibility and advantages of using Venus, when in transit across the sun's disk, for finding the parallax of the sun and therefore its distance. These transits are very rare, but two occurred, one in 1761 and the other in 1769, when great efforts were made and expeditions fitted up. The transit of 1761 was not very successful, but the 1769 transit of Venus, made famous by Captain Cook's expedition to Otaheite in the far Pacific for the purpose of obtaining expert observations from that remote spot, was generally a success. A great deal of valuable data was collected from the various world-wide expeditions, but it was very involved, and precise photographs were naturally absent, so that it was not until 1824 that the data were all finally reduced by Encke (1791-1865) to a definite determination, by computing the average distance of the sun to be 95,000,000 miles.

This value remained the universally adopted standard for half a century, until in 1874, and again in 1882, two more transits of Venus occurred, and again still more elaborate

expeditions went to far-off regions for observations, this time with photography as an aid. Some doubt had arisen about the accuracy of Encke's determination of 95,000,000 miles, and it became evident that this was too great. In the meantime other methods and sources for finding the solar parallax had been discovered:

1 By geometrical methods of direct angular measurement of the parallax of Mars, or preferably some asteroids which approach much nearer to the earth than does the sun, and which are presented as sharply defined points of light, and therefore admirably suited for fine measurement

2 By gravitational perturbations which follow from Newton's famous law (see page 1688) these give the sun's mass in terms of the earth's and thence the distance at which it produces the observed attraction.

3 By the velocity of the earth in its orbit, which gives the radius of the orbit

The general averages of all these methods are in very close accord and reveal that the earth's radius subtends an angle of 8·80 seconds of arc at the sun. This corresponds to an average distance of 92,900,000 miles, and has been adopted by international agreement since 1900.

The distance of 92,874,000 miles obtained as the result of Sir David Gill's parallax of 8″ 802 derived from observation of the asteroids Victoria, Iris, and Sappho, in the year 1889, was the nearest to this ultimately accepted value.

Orbit of Eros

Then came the discovery of Eros in 1898, and its near approach to the earth in 1900 01 provided an ideal opportunity. Observations collected by Hinks gave an average for the sun's parallax as 8″ 806. Thus the possibility of improving on the accepted value of the sun's distance became apparent, but the investigations had to be postponed.

In 1931 Eros approached to as near as 16,200,000 miles of the earth, less than half the nearest approach of Mars and much nearer than any other asteroid had previously been known to do. This was an exceptional opportunity, so in the meantime Sir H. Spencer Jones, the British Astronomer Royal, organized a world-wide co-operation with 25 of the leading observatories in widely separated areas in each continent. In these areas 32 of the largest and best equipped telescopes were to be concentrated upon Eros, more particularly when it reached its best position between the nights of January 27 and February 5, 1931.

Very precise measurements were obtained of its parallax, or apparent shift in position, relative to adjacent stars which, on account of their very much greater distance, appear fixed. The procedure was to photograph the field of view at the same time from widely separated places on the earth, or alternatively from the same observatory, but at widely separated times of the night, as near 12 hours apart as possible. By these means the longest possible base lines were secured for obtaining the parallax of Eros.

Several thousands of photographs were taken in which Eros appeared as a dot ; but when the various photographs are compared each dot is in a slightly different position relative to the other dots which represent distant stars. Either nearly 8,000 miles or at least 12 hours in time will have intervened. All these photographs entailed many years of study and computation to reduce them to their true value by comparison. The mass of evidence had to be analysed, measured, and correlated, one observatory's work with another, times corrected and errors eliminated as far as possible, and discrepancies accounted for.

Ultimately the exact positions of Eros relative to the earth at various times were obtained, and so the orbit of Eros could be constructed mathematically with great precision. This was the essential thing, and the goal was reached for calculating the sun's distance therefrom with equal precision. If the orbit of Eros were a perfect circle with the sun in the centre, this would be a very simple matter ; but its orbit is an ellipse, with considerable eccentricity, and it has two foci, or centres. However, if the size and shape of the ellipse are accurately known, then it becomes easy for a mathematician to find the sun's distance, simply because the sun is always at one of the foci. If the student refers back to page 1685, and consults the three Keplerian laws governing ellipses, this will be seen stated and made clear.

The Harmonic Law

The third of these laws, generally known as the Harmonic law, states that "the square of the time in which each planet completes its orbit is *proportional* to the cube of its mean distance from the sun." It will be noted that the word proportional has been italicised, because "proportional" is not sufficient without a precise example by which to measure the proportion. One planet might be twice the distance of another, but "twice what ?" is the problem.

Eros has provided the precise example. Its elliptical orbit, because of its close approach to the earth, has become known in shape, size, and period to within a few seconds ; therefore the position of the sun in the focus of that ellipse could be known to within 9,000 miles at the most.

So here is a still more accurate measurement of the sun's distance and therefore of everything else in the heavens ; present accepted values will need minor corrections when the new value is adopted internationally for the astronomical unit. This remains to be done, and until this celestial "foot-rule" of 93,005,000 miles is accepted as final, the old standard of 92,900,000 miles will continue to be used

LESSON 6

The Sun's Family of Worlds

Our world is but one of many that travel round the sun. These, together with their moons and satellites, numerous comets, and innumerable meteoric bodies, are all assembled like a celestial archipelago in a vast ocean of space, and situated at an enormous distance from even the nearest stars.

This assemblage constitutes the solar system, and is in reality the sun's family. It can be divided into four distinct classes—planets, satellites, periodic comets, and meteoric bodies. The planets consist of major planets, of which there are nine, and minor planets, of which there are over 2,000 known.

Major and Minor Planets

The major planets in order outwards from the sun are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. The minor planets occupy the space between Mars and Jupiter, a few of their orbits extending to beyond that of Jupiter and within close proximity to the orbit of the earth. None of the minor planets possesses satellites, nor do Mercury, Venus, and Pluto of the major planets. Of the others, the earth has one, the moon; Mars two, Jupiter twelve; Saturn nine; Uranus five; Neptune two.

All the planets travel round the sun in elliptical orbits and in the same direction, Mercury travelling fastest and Pluto slowest, their average speeds being in inverse proportion to the square roots of their distances, in exact accordance with the laws of Kepler. But the ellipticity of their orbits varies considerably, the orbits of Venus and Neptune being almost circular, whereas those of Mercury, Mars, and Pluto are relatively very elliptical, or eccentric—the eccentricity of Pluto's orbit is such that it is an oval about 3 per cent. longer than it is broad; consequently there are great differences in the speeds at which these planets travel in different parts of their orbits round the sun. This is in accordance with Kepler's second law.

Central Orb of the System

The satellites also travel in ellipses round their respective planets, and these likewise vary in eccentricity and speed; it is the rule for the satellites also to move in the anti-clockwise direction, as viewed from the north, like the planets. There are a few exceptions, due to special causes. The orbits of the periodic comets and meteors are in many cases of such great eccentricity that their length is many times greater than their breadth.

So immense is the sun, the central orb of the system, that it outweighs all the planets put together over 700 times; it is this massiveness which provides the gravitational pull that keeps the planets in their observed orbits. The sun has 7,500,000 times the mass of Mercury, 408,000 times that of Venus, 333,420 times that of the earth, 3,093,500 times that of Mars, 1,047 times that of Jupiter, 3,499 times that of Saturn, 22,869 times that of Uranus, 19,314 times that of Neptune.

Considering the comparative diameters of the planets in relation to that of the sun the differences are also very great, for the sun has a mean diameter of 864,000 miles. The mean diameters of the major planets are given, for comparison, in the first column of the accompanying table.

THE MAJOR PLANETS

Planet	*Diameter in miles*	*Mass (Earth = 1)*	*Mean solar distance in millions of miles*	*Periodical time in years*
Mercury	3,030	0·045	36·0	0·24
Venus	7,700	0·826	67·2	0·62
Earth	7,927	1·0	93·0	1·00
Mars	4,230	0·108	141·7	1·88
Jupiter	85,750	318·4	483·9	11·86
Saturn	71,600	95·2	887·1	29·46
Uranus	31,900	14·6	1,786	84·02
Neptune	27,660	17·3	2,797	164·79
Pluto	4,000	?	3,675	248·42

When their mass is considered, a surprising state of things is revealed. The earth is, in proportion to its size, very heavy; it is, in fact, the densest of all the planets, and bulk for bulk about four times heavier than the sun. That is, every average cubic foot of the earth is four times denser than every average cubic foot of the sun. A good idea of the relative densities of the sun and planets, that is, the average weight of the materials composing them as compared with their present size, or volume, can be obtained by comparing them with the density of water.

The earth is 5·52 times as dense, Venus 4·9 times, Mars 3·85 times, Mercury 4·1 times; these are all the heavy planets and the smallest. They are the worlds which have parted with most of their original heat by radiation, and are much more advanced in planetary evolution than the outer and greater planets, except perhaps Pluto.

The density of the other outer planets is similar to that of the sun, which is only 1·41 times that of water. Jupiter is 1·33 times, Uranus 1·26 times, Neptune 1·61 times, while Saturn is, taken as a whole, only about 0·71

that of water. This low density of the great outer planets, although near to that of the sun, does not mean that they are in a similar condition to this very hot and radiant luminary, but that they are, like the sun, composed very largely of gases. The difference is that, whereas the sun's superficial gases are incandescent and at an enormous temperature, the superficial gases of these planets are for a considerable depth below freezing point, as is known to be the case with the earth. The evidence, both telescopic and spectroscopic, indicates that these great outer planets have atmospheres of great depth ; they are always seen to be cloud-laden and so completely covered that it is probable that we never see any of the solid or liquid surfaces of Jupiter, Saturn, Uranus, or Neptune.

Changing Weights

An interesting consequence of the size of the sun and the planets, considered together with their relative densities and mass, is the mean average surface gravity that results. This may be compared with that known at the surface of the earth and the extent estimated as to how much the same body would weigh, more or less, were it transferred to the surface of the sun or any one of the foregoing planets.

Owing to its enormous mass, a body would weigh about 27·89 times more at the sun's surface than it would at the surface of the earth ; only 0·29, or little more than a quarter, on Mercury ; about 0·86 on Venus ; and only 0·37 on Mars. A pound weight would therefore amount to so many ounces if tested by a spring balance on any of these planets, although size and mass would remain the same.

A pound weight would be transformed to nearly 28 lb. at the surface of the sun, notwithstanding its gaseous condition. On Jupiter it would average about 2·64 times as much as on earth, on Saturn about 1·17, notwithstanding its immensity, while on Uranus a pound would weigh about the same as on earth, although its mass is 14·60 times greater. This apparent anomaly arises because gravity, or weight, becomes less the farther the object is from the centre of the planet, in accordance with Newton's laws. In the case of Uranus, its surface is nearly four times farther from its centre than is the surface of the earth. On Neptune a pound would weigh about 10 per cent. more than on earth.

How Density Varies

The student will see from all this that the weight of a body is the force with which the particular planet attracts it ; the extent of this force depends upon the mass, or the amount of matter composing the planet, and also its density, for the force acts as if it were all concentrated at the centre of the planet. Consequently the farther a body or, say, our pound weight, is from the centre of the planet, the less will be its weight as defined by Newton's law. While the mass of a planet is a fixed quantity, because it has so much material and no more, it is otherwise with the planet's density, for this depends upon the amount of space which the aforesaid matter occupies, that is, the planet's volume, or size. Density, therefore, varies with time, place, and circumstances. For instance, loss of heat by radiation will increase density.

It is mass which produces weight, but what that weight will be depends upon how far the planet's surface is from the centre of the mass , and since this depends upon the planet's volume, we see why planets like Uranus and Neptune, which possess a much greater mass than the earth, exert no greater gravitational pull at their surfaces. This is also partly why bodies do not weigh exactly the same at all parts of a planet's surface. Weight is always less at the equatorial regions as compared with the polar, one reason for this being that the polar areas are nearer to the planet's centre owing to the planet's oblateness.

LESSON 7

The Moon and its Influence on Tides

AFTER the sun, the moon is the most important of the celestial bodies—at least, from our point of view. Our calendar is to a great extent based upon its phases, and the tides are mainly due to lunar influence.

The moon, in effect, is a small world, with a diameter of 2,160 miles, as compared with the earth's 7,927 miles. Its surface is only 0·074 and its mass 0·0123 of that of the earth. In other words, the earth has about 81¼ times more material in its composition than the moon has The moon's density is only about three-fifths that of the earth, or 3·34 times that of water. The moon's volume or size is only 0·0203, or about 1/49th, of that of the earth. Hence gravity at its surface is only about one-sixth of what it is on the earth. This leads to some curious results. For instance, an article 6 lb. in weight would, if weighed by a spring balance on the moon, weigh only 1 lb. A ball would travel six times higher on the moon than on the earth, if thrown with the same amount of energy ; and anyone who could jump 5 feet on the earth could jump 30 feet on the moon.

The moon's distance from the centre of the earth varies between 252,710 miles when it is in apogee, or at its farthest, and 221,463 miles when it is in perigee, or at its nearest ; but to us, situated on the earth's surface, the moon really comes nearly 4,000 miles nearer. It is at its nearest when it is due south and high in the sky - just how near depends upon latitude. Its mean distance is 238,860 miles, or about 30 times the earth's diameter.

Lunar Phases

The moon takes, on an average, 27 days 7 hours 43 minutes to revolve round the earth. This is the sidereal month, and it varies sometimes by as much as seven hours. Because the moon is travelling with the earth round the sun, the moon must travel a little farther each month in order to reach the same relative position with regard to the earth and the sun. Consequently the average time from one full moon to another is 29 days 12 hours 44 minutes. This constitutes the synodic month, and this varies sometimes by nearly 13 hours.

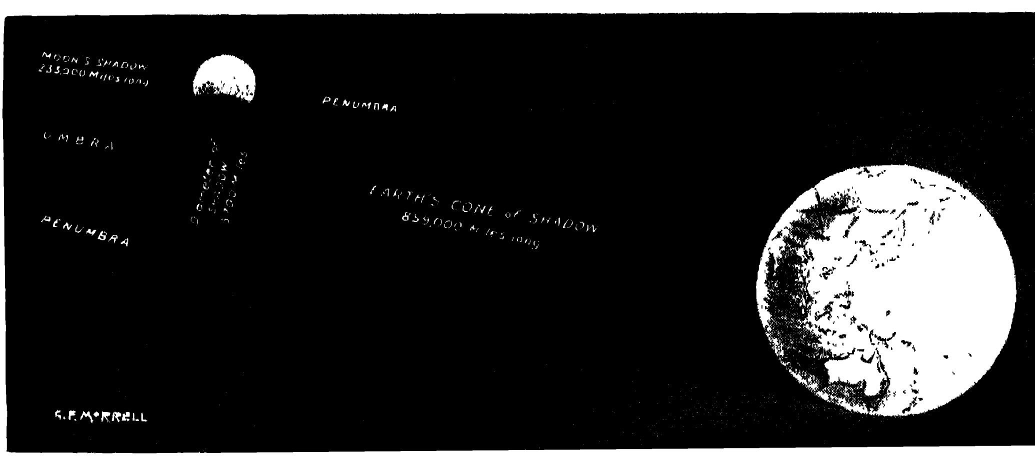
These lunar phases depend upon the place which the moon occupies with regard to the sun as seen from the earth. When the moon is between the earth and the sun, its dark side is turned to us and we say the moon is new. When the earth lies between the moon and the sun we see the moon fully illuminated. Every night the moon wears a different appearance, waxing through the first half of the month, waning through the next half.

If its orbit lay in the same plane as that of the earth, it would pass directly between us and the sun once every month at the time of new moon and would then eclipse the sun, and this does occasionally happen. Then, too, when the moon was full the earth would lie in a straight line between it and the sun, with the result that the earth's shadow would be cast upon the moon, depriving it of the sunlight. This also happens occasionally, as for example when there is a lunar eclipse.

The moon's orbit does not lie in the same plane as that of the earth, but is inclined at an angle of 5° 8½′ (i.e. about ten times the moon's apparent diameter—about half a degree). Consequently the moon, when passing between the earth and the sun, is usually a little above or below the latter, and there is no eclipse. Hence in some years there may be no lunar eclipse, but usually there are two, and even three.

From the computed motions of the earth and moon, it is found that the relative positions of these bodies in regard to the sun repeat themselves with great exactness after a period of about 18 years 11 days, causing a recurrence of eclipses. This cycle period, called the Saros, was observed by the Chaldeans, who were thus enabled to predict coming eclipses. It applies to both solar and lunar eclipses.

There is a great difference between eclipses of the sun, which are described in Lesson 4, and those of the moon, for the moon is obscured only by the shadow of the earth—not by an opaque body, as is the case in a solar eclipse. Consequently the moon never quite vanishes, even at a so-called total eclipse. This is because a certain amount of the solar light that penetrates the earth's encircling atmosphere gets refracted on the moon, thus dimly illuminating its surface. Were we on the moon, we should see a brilliant ring of light encircling the great dark disk of the earth, the earth's



ECLIPSE OF THE MOON. A lunar eclipse is caused when the earth comes between the moon and the sun. The penumbra is the faint shadow produced when only part of the sun is hidden from the moon's surface by the earth. The figures given are average. Thus, while the diameter of the earth's cone of shadow (umbra) where the moon may cross it averages 5,700 miles, it may be some 200 miles more or less than this figure. A partial eclipse is shown here.

disk seen from the moon appearing to be nearly four times wider than the moon appears to us.

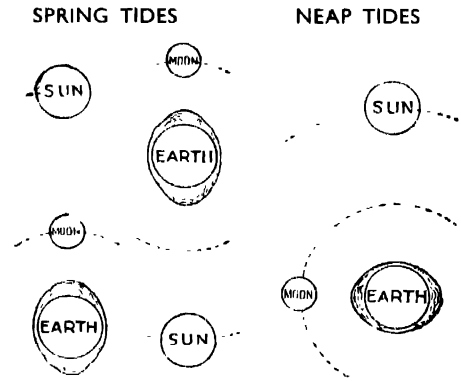
While the earth pulls the moon continually towards itself, the moon also pulls the earth towards its surface. The extent of this pull is somewhat less than the radius of the earth, and as a result the earth performs a small monthly orbit, with a diameter of about 5,806 miles, relative to the moon, in addition to its other motions. This orbital motion is not visually perceptible to us, as the earth as a whole is lifted toward the moon.

The oceans of the world, being fluid, are free to move, and become piled up on that side of the earth which, at the moment in question, is facing the moon. At the same time the solid body of the earth is pulled away from the waters at the opposite side of its sphere, so the water there seems to us as if it, too, were heaped up. Thus we have two simultaneous high tides culminating in two areas of the earth, immediately beneath the moon, as it were, and in direct line with it. But owing to the inequalities of the earth's surface, continents, channels, ocean currents, and the influence of winds, together with minor influences (to say nothing of the sun's tide-raising force, which twice every month acts at right angles to that of the moon), we get high tides that are by no means in direct line with the moon.

Moreover, low tides—which theoretically should occur at places 90° east and west of the high-tide line—are similarly complicated and the low water delayed. In some places, e.g. Southampton, where the tide water enters by two channels, four high tides may occur in a day instead of the two which are actually engendered by the moon.

If the earth did not rotate and the moon were fixed, the water would remain permanently high at one set of places and permanently low at another; but as the earth rotates in 24 hours, the tide-wave sweeps round the earth in the wake of the moon. As the moon in the course of a day has travelled farther round in its orbit, high water occurs about 24 hours 51 minutes after its predecessor, and successive high tides occur at intervals of nearly 12½ hours. Thus it is that tides get later every day.

Because the sun also exerts a tide-raising force (about two-fifths that of the moon), it happens that twice a month, at full moon and new moon, the sun and moon are nearly in line, with the result that the solar pull is added to the lunar. Then we have extra high



CAUSATION OF TIDES. As the earth rotates, its waters become piled up on the side facing the moon, and at the same time the body of the earth is pulled away from the waters at the opposite side of the globe.

tides, or spring tides as they are called. If these occur when the moon is near perigee, we get extra high spring tides. When the sun and moon lie at right angles to one another with regard to the earth, and the moon is in its first or last quarter, their tidal forces are opposed – with the result that we have what are called moderate or neap tides.

Allowing for all these factors, the average height of a spring tide may be regarded as rather more than double that of a neap tide at any particular place. In the open ocean the average range of the tides is only about 2½ feet, but in shallow waters and narrowing channels, bays, and gulfs, it is greatly increased, sometimes to 40 and 50 feet.

One effect of the tides has been to act as a brake upon the rotation of the earth, and so to lengthen the day. In the early period of the earth this braking effect was much greater than at present, and Sir George Darwin calculated that tidal friction has had the effect of lengthening the day from about three hours to 24

LESSON 8

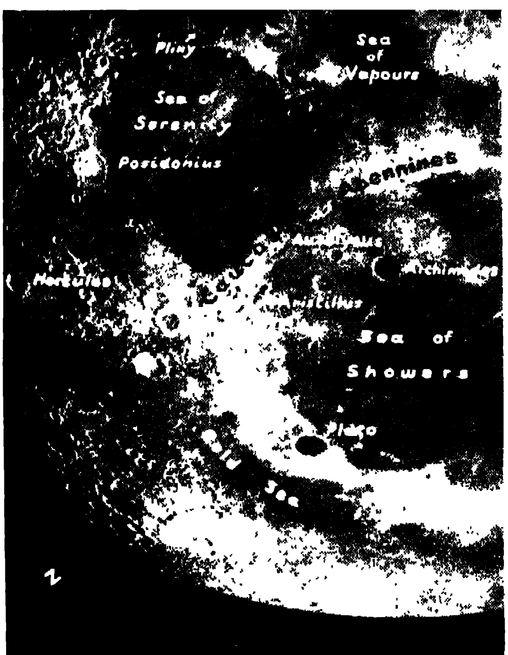
The Moon a Dead World

To the naked eye certain distinct markings are perceptible, which are successively lit up as the sunlight extends across the moon's face from the thin crescent phase to full. In the early days of telescopic observation the darker parts were regarded as seas. They were named as indicated by the following letters in the photograph on page 1699: B, Mare Nubium; C, Mare Nectaris, D, Mare Fecunditatis E, Mare Tranquillitatis; G, Mare Vaporum J, Oceanus Procellarum; K, Mare Crisium L, Mare Serenitatis; O, Mare Imbrium.

All these may once have been watery wastes on this side of the moon There are indications, such as cliffs, bays, and a relatively smooth and less broken surface, which suggest the action of water, or molten matter, long ago. If water was present, it has long been absorbed by the rocks as the body of the moon cooled.

All these features are easily discerned with binoculars or good sight. During the progress of the phases it will be seen that the line dividing the bright from the dark part of the lunar disk is uneven, and that its details change from evening to evening, at times resembling the profile of a human face. This dividing line between night and day on the moon is called the terminator. When the phases are progressing from new moon to full, it represents the region where the sun is rising ; when the phases are passing from full moon to new, the terminator represents the region of sunset. The horns, or cusps, of the crescent are always facing away from the sun, and a straight line joining their tips is always at right angles to a line from the moon to the sun. The smooth edge or circumference of the moon's disk is called the limb.

Because the familiar details on the moon's disk are seen to be always there, it is obvious that we never see the other side. That is because the moon rotates on its axis in precisely the same time that it takes to revolve round the earth ; this is the moon's sidereal day, which lasts for nearly 27⅓ of our days. The moon consequently always presents almost exactly the same face, but owing to libration (that is, a certain oscillation of our satellite relative to the earth), and to the fact that we are on occasions, such as at its rising and setting, able to see a little farther round the edge, as it were, of the moon, altogether about 59 per cent. of the surface is observed.



NORTHERN SECTION of the lunar disk. It should be borne in mind that photographs of the moon's surface are represented as viewed through a telescope, that is, reversed, and consequently the north polar region is at the bottom here. The dark areas, to which the name seas has been given, are probably vast plains of solid larva. The photograph was taken at Mount Wilson observatory in 1925

Lunar Mountain Ranges

If the moon is observed with binoculars or field-glasses, the serrated edge of the terminator between the night and day regions is at once obvious. Bright portions will be seen to project into the dark area and sometimes be observed detached from the bright area ; these are the lofty eminences, the mountain ranges and high crater walls lit up first by the rising sun. They will be seen in the course of a few hours to merge into the rest of the sunlit portion, and then others will appear ; thus it becomes possible with little magnification to perceive the larger craters and ranges

The chief lunar mountain ranges attain great heights , these can be measured with accuracy by means of the shadows they cast The following is a list of the chief of these ranges, together with heights in feet · Alps, 14,000 feet, and Apennines, 18,000-21,000 feet, shown at R and M respectively, in the photograph on p. 1699 ; Altai, 13,000 feet ; Caucasus, 18,500 feet , Pyrenees, 12,000 feet ; Doerfel Mountains, 26,000 feet ; Leibnitz Mountains, 30,000 feet ; Mount Taurus, 10,000 feet The photograph on this page of the northern section also shows the Apennines and the Caucasus, as well as some of the craters.

Vast Craters

The moon's most notable features are the craters and the so-called walled plains. Many of these are perceptible with binoculars if observed when near the terminator dividing line, for there long shadows are cast by the sun, which is rising or setting over that area.

The lunar craters may vary in size from a mile or less in diameter to 50 or 60 miles, the small craterlets often encircling the larger ones and forming a very striking feature of their terraced walls. The crater of Copernicus (marked H in the photograph), which may be taken as typical, is 56 miles in diameter, so it would occupy all the space between, say, London and Eastbourne, or York and Manchester. The terraces rise to peaks which reach a height of 13,500 feet and average about 11,000 feet above the bottom

of the crater. In the centre of the floor rises a six-headed central mountain to a height of about 2,400 feet.

Walled Plains

These central peaks are a feature of the craters. They may be the remains of a central cone of eruption, but there are diverse opinions among experts as to how these craters came to be formed. Some authorities have ascribed to them a meteoric origin instead of a volcanic, as in the case of terrestrial volcanoes, the craters of which never exceed seven miles across. The moon having no appreciable atmosphere, its surface would be much exposed to meteoric bombardment, and it has been asserted that huge meteors, striking the semi-plastic crust of the moon ages ago, would have produced just this effect. It is possible that both causes have operated in the formation of the craters.

FEATURES OF THE MOON. This photograph of the moon when 14 days and 8 hours " old " was taken at Lick observatory. The principle "seas" are lettered and the names are given at the foot of page 1697. Craters shown are : A, Tycho ; F, Ptolemy ; H, Copernicus ; N, Archimedes ; P, Aristarchus ; Q, Plato. Two mountain ranges, the Apennines and the Alps, are shown at M and R.

As regards the enormous walled plains, these are more difficult to explain upon the volcanic theory, particularly since the central peaks are usually absent. Instead, a vast level plain generally studded with craterlets exists, while a more or less circular range of distant mountains forms a remarkable ring, which may be over 100 miles in diameter, composed of lofty peaks and numerous craters, which form a circle, as in the case of Clavius. This has a diameter of 142 miles, with an encircling wall of mountains reaching to a height of 17,300 feet and including many minor craters.

Plato and Tycho

Plato, shown at Q in the photograph above, is another of these walled plains. It resembles a vast crater that has enclosed, in the distant past, a lake of lava 2,700 square miles in extent. The terraced mountains attain a height of approximately 9,000 feet.

Tycho, shown at A, is the most striking of all the hundreds of craters present, particularly at full moon. The remarkable series of bright rays or streaks extending for many hundreds of miles in every direction constitutes a singular formation that is best seen then. They pass across valleys and mountains, craters and rifts, at an average width of about five miles, and remain one of the mysteries of the moon. Tycho itself is a superb crater 54 miles in diameter and 17,000 feet deep ; from this floor rises a central mountain to a height of between 5,000 and 6,000 feet.

Numerous craters and other formations are partially broken down, particularly round the so-called seas, or maria, as if these had been seas of molten lava that had melted them, or water had been capable of washing away their walls. Other features are deep clefts that extend for hundreds of miles, and deep valleys called rills.

Desolation Everywhere

Everywhere is desolation. It is certain that the moon is a dead world with no perceptible atmosphere. Such air and water as the moon may once have possessed must have been absorbed into its substance, or have diffused away into space ; therefore its surface must undergo extremes of heat and cold far beyond anything experienced on earth, attaining a mid-day temperature of about 220 degrees

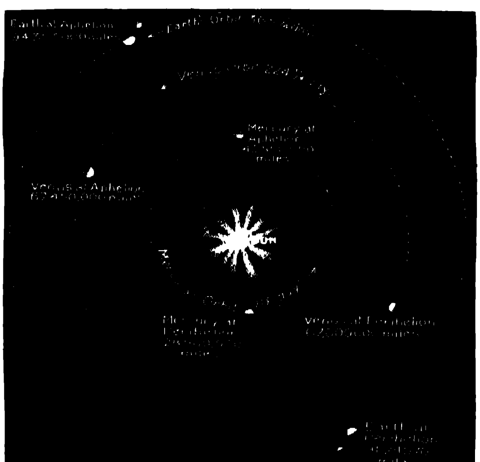
Fahrenheit and a night temperature of about 200 degrees below zero. In some deep craters and clefts, sheltered from such extremes of temperature, lowly forms of life have been suspected to exist, the evidence being changes of colouring. The moon may perhaps be a part of the earth that became detached through tidal strain when they were both molten ; in this case it is probably composed of materials similar to the earth's. It may be an independently formed planet, never part of the earth. Its origin and past history are still quite unknown.

LESSON 9

Mercury, the Planet Nearest the Sun

Of the five planets known since ancient times, Mercury is the one most rarely seen in these latitudes. Owing to its proximity to the sun, it never appears more than from 18 to 28 degrees east or west of the latter, and in consequence has always to be observed against a twilight sky and at a low altitude, where the mists and cloud near the horizon often obscure it.

It shines as a bright first-magnitude star with a slight golden hue, and always appears either as an "evening star," east of the sun, or as a "morning star," west of the sun. The ancients regarded these two apparitions of the planet as different objects, the "morning star" being called Apollo. It never appears at night. Mercury is best seen in the evening in March or April, between one and two hours after sunset ; or in the morning, between one and two hours before sunrise, in September or October.



VENUS, MERCURY, AND THE EARTH. **The orbits of the three planets which keep nearest to the sun are shown, with their positions of aphelion (point farthest from the sun) and perihelion (nearest the sun) respectively. All planetary orbits are elliptical, but that of Venus approaches most nearly to a circle. Because Mercury is so near the sun, observation of this planet is at all times difficult.** **See also the diagram in page 1701.**

On favourable occasions Mercury approaches the earth to within 50,000,000 miles ; at other times it will not come nearer than 65,000,000 miles. This is because of the great eccentricity of its orbit —0.206 ; at aphelion it is 43,500,000 miles from the sun, 28,500,000 miles at perihelion.

A consequence of the great eccentricity of Mercury's orbit is that the speed at which it travels varies from about 24 miles a second when at aphelion to about 36 miles a second at perihelion. This latter is just twice the speed of the earth which is about 18 miles a second, on average.

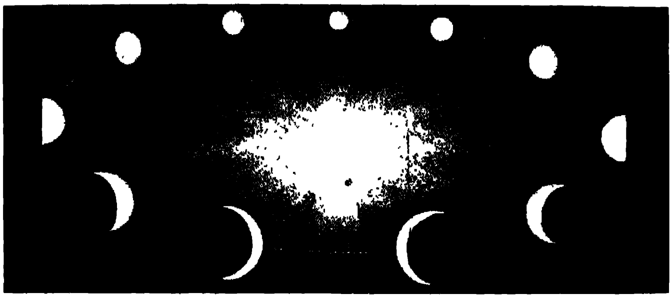
Mercury takes only 88 days to complete its journey round the sun, or sidereal period, but it takes 116 days (synodic period) to come back to the same position relative to the earth and sun. The plane of its orbit is inclined at an angle of 7 degrees to the ecliptic or the plane of the earth's orbit ; this is more than the inclination of any other major planet's orbit, except that of Pluto. Being very much less in evidence than the brilliant Venus, the motions of Mercury are not obvious, but the orbits of Mercury and Venus are within that of the earth.

Inferior and Superior Conjunction

Both Mercury and Venus present all the phases of the moon, although these differ in detail. When the planet is approximately between the earth and the sun, its unilluminated side is presented toward us, and although it is then at its nearest we do not see it.

When either Mercury or Venus is placed between us and the sun, it is said, at the moment when either planet is exactly north or south of that luminary, to be in *inferior conjunction* with the sun. When either Mercury or Venus passes beyond the sun, whether above, below, or behind the solar disk, it is said to be in *superior conjunction*. It is then that they present a full disk (which the brilliance of the sun obscures) and are at their greatest distance from the earth. For Mercury this may amount to about 136,000,000 miles.

We see Mercury and Venus when they appear to swing left or right — that is, east or west of the sun. If, when they are beginning to be visible as "evening stars," they are observed through a telescope, they will appear small, almost circular, and near the sun.



MERCURY'S ORBIT. This planet presents all the phases of the moon and its apparent changes are seen in this diagram. Mercury takes the same time to complete its journey round the sun as it does to rotate once on its own axis. See also the diagram in page 1700.

In the course of a few days in the case of Mercury, a few weeks in the case of Venus, they will appear to travel eastward away from the sun, become larger (or to the naked eye, brighter), and gradually assume the shape of a half-moon—*quadrature*, it is called. They will then be near the extremity of their eastern swing or *elongation*. Next the crescent phases supervene, the planet appearing to grow larger until, when about midway between quadrature and inferior conjunction, Mercury or Venus, as the case may be, arrives at its greatest brilliancy. Although the planet approaches still closer, the crescent will continue to grow thinner and less brilliant as it seems to get nearer to the sun and inferior conjunction.

When this occurs, it occasionally happens, if Mercury is near its node, that it comes directly between the earth and the sun ; then the planet appears as a small black disk in transit across the sun's disk. Transits of Mercury always occur on or near May 7 or Nov 9, which represent the two nodes of its orbit. The last (at the time of writing) took place on Nov. 13, 1953.

With a diameter of only 3,030 miles, not much more than one-third that of the earth, Mercury has a surface barely one-seventh as extensive. Because of its proximity to the sun, observation of any details on its disk is difficult, but from time to time sufficient dark permanent markings have been noted to indicate that Mercury revolves but once in the course of a revolution round the sun. Thus its day must be about 88 of our days in length ; and just as our moon always presents the same face to the earth, so Mercury has ever the same hemisphere facing the sun.

There is no evidence of an atmosphere on the planet ; low *albedo*, or light reflection - 0·07 suggests that its light is reflected from a dark and broken solid surface, similar to that of the moon, and not from clouds. Moreover, the force of gravity on Mercury would be insufficient to enable it to retain atmosphere.

Conditions on Mercury must therefore be vastly different from what we experience on the earth or even from those on the moon. For while the immense solar disk would, as seen from over the greater part of one hemisphere of Mercury, appear permanently in the sky, from the other the sun would never be seen, except possibly from the polar regions and a narrow belt a hundred miles or so in width bordering the dividing line between night and day.

Over this latter region the sun would rise a little way above the horizon and then set again in the course of about 44 of our days. The frigid conditions of Mercury's night hemisphere must be intense, and its hemisphere of perpetual day would be hot enough to melt lead.

The existence of a world between Mercury and the sun—an intra-Mercurial planet—was for long conjectured, owing to a perceptible acceleration of Mercury in its orbit which could not be otherwise accounted for. This acceleration is known as the advance of Mercury's perihelion. Several times during the last century the discovery of such a planet was claimed, the most noteworthy being in 1859, when the supposed planet was named Vulcan. Its existence has never been established, and the advance of Mercury's perihelion has since been accounted for by Einstein's theory of general relativity.

LESSON 10

Venus, Sister Planet to the Earth

VENUS is the sister planet to the earth, and the most brilliant and easily recognized of all the sun's family of planets. It is commonly known as the " evening star " when it appears in the western sky, and as the " morning star " when it is in the eastern sky. As in the case of Mercury, the ancient astronomers regarded its two appearances as separate luminaries ; the Greeks named them Hesperus and Phosphorus respectively.

Venus will remain for seven or eight months at a time the most striking object in the evening sky, shining with a pearly lustre far exceeding any other star or planet. Then it will vanish, and reappear in less than a month in the morning sky, having in the interval passed between

the earth and the sun. Venus passes through a complete series of phases as seen from the earth. The planet takes about 584 days to complete a series from one inferior conjunction to another. This *synodic period* represents the time occupied by Venus after passing the earth at, say, inferior conjunction, until it again returns to a similar position relative to the earth and sun. The synodic period is exceptionally long because Venus is travelling at about 22 miles a second, whereas the earth travels at nearly 4 miles a second slower, and hence takes time to catch up to the synodic point of Venus

Visibility and Brilliancy

It takes Venus 224·7 days to perform its revolution round the sun ; this is its "sidereal period" and constitutes the length of the planet's year. Its distance from the sun averages 67,200,000 miles, and varies to the extent of about 500,000 miles each way to aphelion and perihelion ; thus the orbit of Venus approaches nearer to a circle than any other planet. It approaches the earth to within about 25,000,000 miles, and so comes nearer to us than any other world except the moon ; but on such occasions Venus is usually invisible, owing to the fact that it is between us and the sun, so that its dark hemisphere is turned towards us.

As in the case of Mercury, Venus is best observed when near eastern or western elongation, as then it appears to swing to its greatest angular distance from the sun, as seen from the earth, and sets between four and five hours after the sun. On these occasions it appears high in the south-west sky, and is well placed for observation. Its greatest brilliancy is attained about five weeks later, when it appears as a broad crescent similar to that of the moon two days before the first quarter

In the early morning sky Venus attains greatest brilliancy about five weeks after inferior conjunction. So brilliant is it at these times that it will cast a distinct shadow on a dark moonless night and, if its position is known, it can be seen in daylight while the sun is shining.

Size of Venus

The diameter of Venus is about 7,700 miles, as compared with the earth's equatorial diameter of 7,927 miles ; its surface is therefore nearly (0·95) as large as the earth's. It appears to be generally enveloped in clouds, whose great reflective power has the very high albedo of 0·60 - the degree of albedo being the proportion of light reflected of that which is received from the sun. This brilliance, while making Venus a splendid object visually, causes it to be disappointing telescopically, because so little detail is perceptible on its intensely luminous surface.

That it has a dense atmosphere is proved by the prolongation of the cusps of the crescent. Then, too, when Venus is about to transit across the sun's disk, a brilliant ring of refracted light is seen to surround the planet's black disk as it enters upon the sun. This is produced by the sunlight passing through the atmospheric envelope of the planet. Spectroscopic tests confirm the existence of this atmosphere, but it is difficult to decide its composition, as the lines in the Venus spectrum are involved with those of the spectra of the sun and earth.

Since nearly all, or perhaps all, of the light from Venus is reflected from the lofty surfaces of the cloud envelope, spectroscopic evidence of what lies below is difficult to obtain. Expert investigation has found less than 0·1 per cent. of oxygen in that part of the atmosphere of Venus that is above the clouds, by comparison with that of the earth, and hence some authorities claim that Venus cannot have any vegetation or higher forms of life It should be borne in mind that the higher layers of the earth's atmosphere would also give very little evidence of the oxygen present in the lower layers to, say, an investigator stationed on Mars, if it were covered with clouds

Life on Venus ?

Owing to its greater proximity to the sun, the latter appears nearly half as wide again as seen from Venus compared with the earth, while it pours down upon the planet about twice as much light and heat as it does upon our world. The fact that heat has been found radiating from the dark night side of Venus suggests a fairly equable temperature maintained by a cloud-laden atmosphere of considerable density.

An important addition to knowledge of conditions on Venus was made in 1932, when at Mount Wilson observatory (near Los Angeles, U.S.A.), Dr. W. S. Adams and Dr. Theodore Dunham discovered that there was sufficient carbon dioxide for the maintenance of vegetable life on Venus ; and from this it might be inferred that animal life, too, may exist.

Such questions cannot be settled until the period of the planet's rotation on its axis, i.e the length of its day, has been decided. At present there are wide differences in the estimates put forward, as these include 23 hours 20 minutes ; 68 hours ; and 224·7 *days*. The last is also the period of its rotation about the sun, and if it be correct, then the same hemisphere would be always facing the sun and life would be impossible over most of the planet

Visual observation and spectroscopic evidence have been supplemented by photography by ultra-violet rays. These penetrate the brilliant white radiance of the cloud surface sufficiently to obtain more definite markings, and evidence has been obtained of more rapid motion than can be reconciled with the 225-day period. The confusing factor is the unknown tilt of the

planet's axis, but taking into account all that has so far been discovered it seems likely that Venus rotates in a period amounting to between 24 and 30 of our days. These long days of Venus are theoretically what might be expected in a world which has through the ages been subject to much greater tidal retardation from the sun than has our world. The absence of polar flattening may be accounted for by the planet's slow rotation. Another line of speculation suggests that Venus is entirely covered by ocean. This seems to be in keeping with a planet devoid of vegetation, covered by cloud, and with carbon dioxide in its atmosphere.

Transits

The transits of Venus (i.e. when the planet passes so exactly between the earth and the sun that it is presented to terrestrial observation as a black disk) provided astronomers with a welcome opportunity of accurately measuring the earth's distance from the sun by means of a simple trigonometrical process. Two observers, A and B, stationed one at each end of a measured base line on the earth, see the disk of Venus projected on the sun at a and b. The length of the line joining a and b on the sun bears the same relation to the length AB on the earth as the distance between Venus and the sun does to the distance between Venus and the earth. This ratio being known from Kepler's laws, it is easy to calculate how far away the sun must be. The astronomer Edmund Halley was the first to suggest this method, in 1716 (*see* Lesson 5).

Transits of Venus across the sun always occur on or about June 7 and December 8, and always come in pairs, e.g. the transits of June 1761 and June 1769. These were followed by the transits of December 1874 and December 1882. The latter was the last, and the next pair will not occur until June 8, 2004, and June 6, 2012. The transit of Venus was first observed by the astronomer Horrocks (1619–41) in 1639.

LESSON 11

Astronomical Basis of the Calendar

THERE is now to be considered the third planet of the solar system, the earth—the moving platform, as it were, from which we observe all other celestial bodies. The student has learnt how, as the result of the earth's motion, the stars appear to move in one vast body from east to west, and complete the circuit of the heavens in nearly 24 hours; this is the Apparent Diurnal Rotation of the heavens due to the earth's rotation.

Also there is the Apparent Annual Rotation of the heavens due to the earth's revolution round the sun; in this an additional rotation of the heavens occurs, so that they appear to rotate 366 times in 365 days. Then there are the apparent paths of the sun, moon, and planets.

Sections of the Zodiac

Most of this movement is only as it appears from our point of view; it is continually changing and highly involved owing to the motions of the celestial bodies themselves. There is a general movement of the sun, moon, and planets in addition to their apparent diurnal motion across the sky from east to west; this is their apparent path through the heavens from west to east, in the case of all except the inner planets, Mercury and Venus, which (as previously pointed out) exhibit motions due to perspective, peculiar to themselves. They all, except Pluto, follow paths which are contained within a belt of the sky 18 degrees wide and 9 degrees each side of the ecliptic, which is the sun's apparent path.

This belt or zone, called the zodiac, is divided into 12 sections, each 30 degrees wide and constituting one of the signs of the zodiac. Each sign has a symbol, and is named after a constellation which, however, does not correspond to the area represented by the sign; the reason for this will be explained later. The names of the signs from first to last are:

Aries (♈)	Leo ( )	Sagittarius (♐)
Taurus (♉)	Virgo (♍)	Capricornus (♑)
Gemini (♊)	Libra (♎)	Aquarius (♒)
Cancer (♋)	Scorpio (♏)	Pisces (♓)

Each of these signs represents the arc of the heavens traversed by the sun in a twelfth part of the year. Beginning with the first point of Aries on March 21 (March 20 in leap years), the sun passes through the first three signs in spring; the next three during summer, which begins on June 21, when the sun enters the sign of Cancer; the next three signs are passed through during autumn, which begins when the sun enters the sign of Libra—usually on September 23; the last three signs are passed through in winter, after the sun enters Capricornus on December 22.

This apparent movement of the sun through the signs of the zodiac reflects the earth's motion round the sun in a period known as the tropical year, or year of the seasons, being 365 days 5 hours 48 minutes and 46 seconds in length. Since each successive year is nearly 6 hours longer than the civil year of 365 days, every fourth year (leap year) a day is added to the civil

year to adjust it to the tropical year as represented by the sun.

This was the chief feature of the Julian calendar as ordained by Julius Caesar, in accordance with the plans of the astronomer Sosigenes of Alexandria, in 45 B.C., with the object of adjusting the extensive errors which had crept into the civil year, as compared with that represented by the sun. At the same time the beginning of the year was changed from March to January 1—a date which, unlike March 21, the beginning of the tropical year, has no astronomical significance.

Pope Gregory's Calendar

The Gregorian calendar was introduced in A.D. 1582 further to adjust the calendar to the tropical year, because the Julian calendar had left 11 minutes 14 seconds to be disposed of, and this had resulted in an error of 10 days since its adoption. Pope Gregory, in accordance with the suggestions of the astronomer Clavius, ordered these 10 days to be omitted; that in future all century years, which would otherwise have been leap years, such as 1700, 1800, and so on, should be regarded as normal years, with the exception of such century years as 1600 and 2000, which are divisible by 400.

It was not until 1752 that the Gregorian calendar was adopted in Britain, by regarding September 3 of that year as September 14: 11 days were then sacrificed to bring the calendar into approximate conformity with the tropical year and the position of the sun. The Gregorian calendar was only gradually adopted: by Italy, France, Spain, and Portugal in 1582; by Switzerland, Holland, and Flanders, Prussia, and the German Catholic states, in 1583; Poland in 1586; Hungary in 1587; Denmark, the Netherlands, and the German Protestant states in 1700; Sweden between 1700 and 1740, by omitting leap-year days; the British colonies in 1752; Japan in 1872; China in 1912; Bulgaria in 1915; Russia and Turkey in 1917; Yugoslavia and Rumania in 1919; Greece in 1923– by which time the difference between the so-called Old Style and New Style was about 13 days.

Recent leap years have been 1944, 1948, 1952, and 1956, and they will recur every four years. This plan of adding and subtracting days to adjust the discrepancies between the earth's diurnal rotation period and the period of its revolution round the sun, or tropical year, still leaves some minor discrepancies, but these will not be appreciable for many thousands of years.

The period of the earth's annual revolution relative to the stars, called the sidereal year, is 365 days 6 hours 9 minutes 9½ seconds. Inasmuch as this completes the earth's orbit in space, it is the true year; but as it does not conform to the sun's apparent motion from season to season, it cannot be used as a convenient basis for the calendar year.

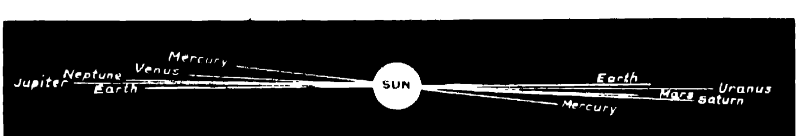
The student is already acquainted with the fact that what appears to be the sun's path through the zodiac is really the earth's path projected against the stars in the depths of space beyond. This path is called the ecliptic, and it represents the plane of the earth's orbit. Because the paths of the moon and all the principal planets, except Pluto, are contained within 9 degrees of each side of this ecliptic or plane of the earth's orbit, the planes of each of their orbits can depart but little from the level of that of the earth.

Sidereal Days

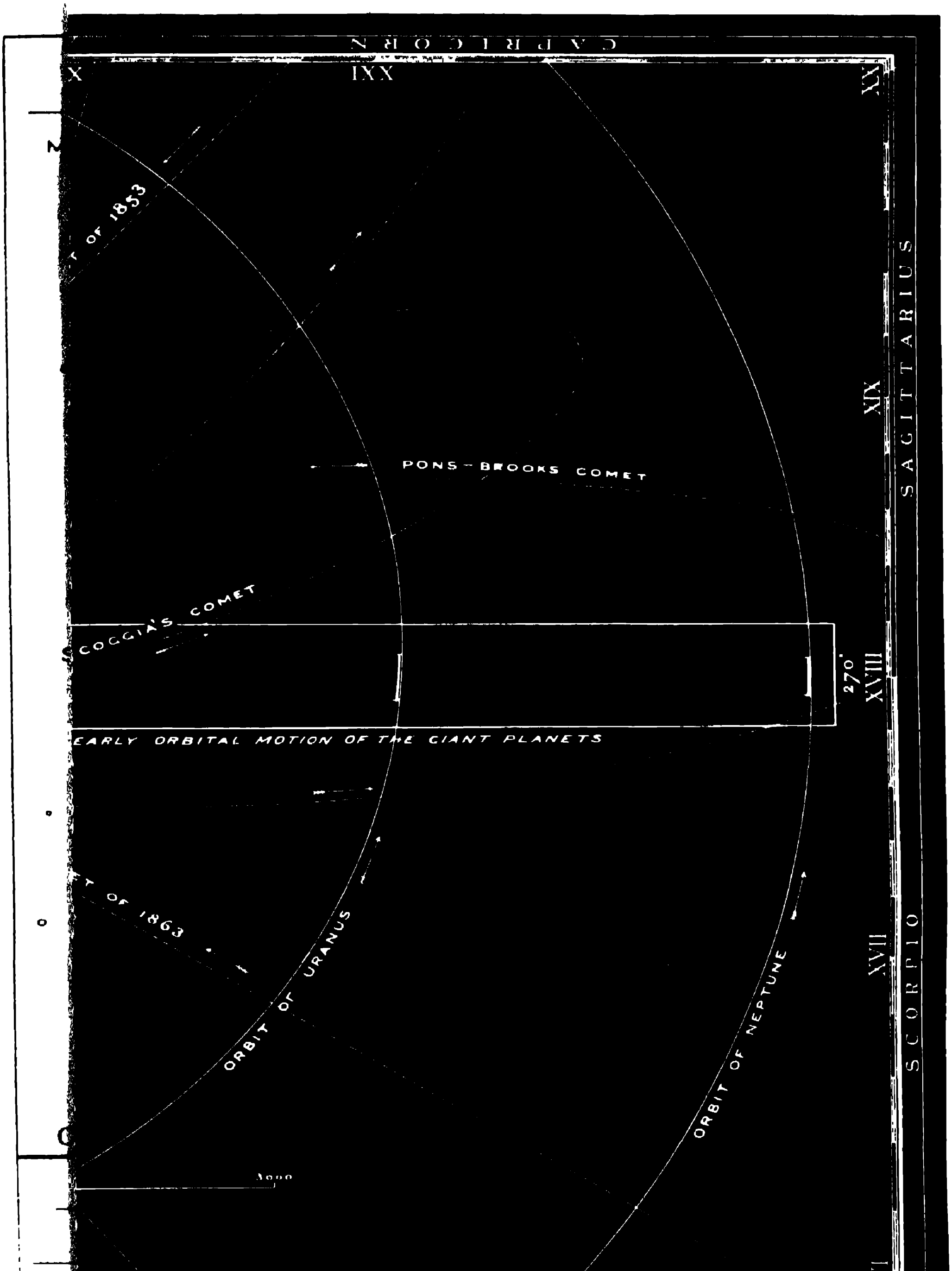
In calculating the length of the year the normal day of 24 hours is taken as the unit of time. This natural unit is based upon the average time which the sun appears to take to return to its highest point in the sky. It occurs at noon, and hence from noon to noon constitutes a solar day; but actually the 24 hours of the solar day represent the time that the earth has taken to turn once on its axis so as to bring us round directly to face the sun again, which occurs at the hour of noon.

This constitutes one rotation of the earth relative to the sun, but not to the heavens generally. If the student were to note the exact minute at which a star, high up in the south, reached a certain point relative to, say, a church spire or a tree-top, and then watched for the same star to reach the same position on the next night, he would find that it arrived there nearly 4 minutes earlier by the clock, i.e. by solar time.

These sidereal days, as they are called, represent the time taken for the earth to turn on its axis to bring us round to face a certain star again; since this amounts to about 23 hours and 56 minutes, while there are nearly 365¼ days of 24 hours each, i.e. solar days, in a year, there are about 366¼ sidereal days. The exact length of the sidereal day is 3 minutes 55·91 seconds less than the solar day. The earth's motion round the sun is not, on account of its varying distance from the sun, quite uniform or always



PLANETARY PATHS. With the exception of that of Pluto, the paths of all the principal planets are within nine degrees of the ecliptic. This diagram shows the inclination of each planet's orbit compared with that of the earth.



lliptical orbits of the comets are shown by dotted lines   Within the white rectangle
of the orbit, Jupiter taking nearly twelve years for each revolution

ASTRONOMY, LESSONS 6, 12, and 19

at the same rate ; consequently the sun does not always precisely indicate noon at twelve o'clock. Apparent solar days vary, therefore, in length ; to get over this difficulty an exact equalisation of the variations has been made, called the equation of time, and the result is the mean solar day of 24 hours as indicated by all clocks and watches that are in proper accord with chronometers. This " mean time " is artificial, but the only practicable scheme in the circumstances. If we were to set our clocks by sundials, we should find that 24 hours would vary in length by several minutes at certain times of the year.

The most regular of all movements is the earth's rotation ; and, though not absolutely exact, its variations are inappreciable in a century. This rotation occupies 23 hours 56 minutes 4·09 seconds out of a solar day of 24 hours of mean time, and constitutes a sidereal day. The sidereal day is used by astronomers as the basis of exact time, but it is not practical for daily use because as it is shorter by nearly four minutes, all clocks would need to be rated to run fast by this amount every day. Thus the clock would no longer agree with the sun, and noon would occur at all hours of the day and night.

LESSON 12

The Six Superior Planets

THE outer, or superior, planets are those whose orbits lie outside that of the earth relative to the sun. They are Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto, and their respective distances and order outwards from the sun, together with their relative sizes, are given in the table on page 1694. Mars, Jupiter, and Saturn appear as brilliant objects of the night sky, one or another being usually present ; Uranus is only just perceptible to the unaided vision ; to see Neptune and Pluto requires a telescope.

All the orbits of these outer planets traverse the zodiac, except that of Pluto, which during part of its course extends beyond the limits of the zodiac.

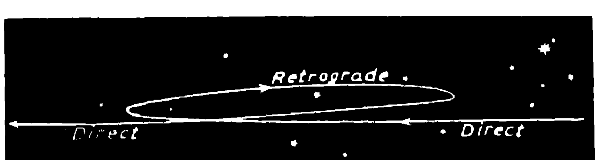
While sharing the common diurnal motion from east to west of all celestial bodies, the six planets also participate in the annual sidereal motion of the heavens, which causes them to appear first in the east and then gradually, in the course of several months, to descend into the west, setting earlier each evening. In addition, there is each planet's own orbital motion, perceived mostly as direct, toward the east, but partly as retrograde, toward the west. Actually the planet's motion is always toward the east, as viewed from the sun ; but because the earth travels faster than any of the outer planets, there comes a point—when the earth and the planet in question are approaching their nearest—when the overtaking earth causes the planet to appear to move backward among the stars. This illusion is precisely similar in effect to that produced upon a passenger in a fast-moving train as it passes one that is moving less quickly ; the latter appears to move backward in relation to the landscape beyond.

The entire course of an outer planet's movements, as observed from our rapidly moving world, can be concisely summarised. Beginning with conjunction with the sun—that is, when the planet passes through the point of its orbit which lies directly behind and beyond the sun—the earth, the sun, and the particular planet are in a straight line ; the planet is then invisible to us, being lost in the solar radiance. In the course of three or four weeks after conjunction the planet will begin to be seen in the dawn.

Course of Planetary Movements

As the more rapid motion of the earth brings the planet more and more into view, so it will rise earlier—ultimately before midnight. Gradually, as the earth catches it up, so to speak, the planet becomes brighter and apparently larger as observed telescopically. As it approaches nearer, its apparent motion will diminish, until it appears to become stationary in the heavens ; then, in a day or so, movement may be detected, but now it seems as if it is moving in the opposite direction, i.e. it is retrograding. This is due to perspective and to the fact that the earth is travelling faster and along a track within that of the other planet.

The planet will continue to retrograde for some weeks, the length of time being in proportion to its distance and the speed at which it is travelling. Mars, the planet which comes nearest, will take, on average, 70 days ; Jupiter, travelling slower, about four months.



COURSE OF A PLANET, showing how the retrograde and direct movements combine to form a loop. This diagram illustrates the path of Mars among the stars of Cancer from October 1930 to May 1931.

Meanwhile the distance separating the earth from the planet will now rapidly diminish, and the planet will appear higher in the sky toward midnight, until it will reach its highest point and be due south at midnight. The planet will then be at the opposite point of the heavens to the sun and in what is called opposition. This is usually the most important stage of an outer planet's path through the heavens as observed from the earth, because then it is at about its nearest to us, at its greatest altitude above the horizon, most extensively illuminated, and therefore best situated for telescopic study.

After opposition the planet becomes a prominent object high in the south of the evening sky between sunset and midnight. It is now receding from the earth, becoming less bright, and its motion becoming slower, until the planet becomes stationary again. It then resumes its direct motion eastward. Usually the retrograde motion combined with the direct takes the form of a loop, or a returning curve above or below the direct path; this is because the planet's orbit lies in a slightly different plane from that of the earth. Travelling rapidly eastward among the stars, and at the same time setting earlier each evening, the planet will sink gradually toward the west, until it is ultimately lost in the sunset glow. It is now far beyond the sun and will soon be back in conjunction again. Thus ends each successive apparition an apparition being one entire course of an outer planet from the time it is first seen in the dawn after conjunction until it is lost in the evening twilight months later.

Synodic Period

The entire series from one opposition to another, or between two conjunctions, constitutes the synodic period of the planet, and represents the interval between the occasions when it is in the same relative position to the sun as seen from the earth. The synodic period is longest in the case of Mars, two years and about 50 days; 399 days for Jupiter, 378 days for Saturn, 370 days for Uranus, 367½ days for Neptune. It is most for Mars because this planet's speed is greatest (15 miles a second), and also because the orbit of Mars is the smallest relative to that of the earth.

The sidereal period is the true period representing the time the planet takes to revolve around the sun relative to the stars; the synodic period represents the time the planet takes to revolve round the sun relative to the earth. For instance, imagine ourselves situated in space so that we see the sun, the earth, and, say, Mars in a line, with Mars at the opposite end of the line to the sun: watching them from that moment, we should see that the earth, after passing Mars at the time of opposition, when it was in line with the sun, would perform more than two journeys round the sun before again being in line with Mars and the sun.

From a single observation it cannot be said whether a planet is one which revolves about the sun beyond the earth or whether its orbit lies within that of the earth. As the ancients well knew, however, Mercury and Venus never depart very far in the sky from the sun: they are twilight objects, never being above the horizon at midnight. This phenomenon is so marked in the case of the innermost planet that it is safe to say that most people pass the whole of their lives without ever seeing Mercury. It is otherwise with the superior planets: they are most conspicuous when they are in opposition, i.e. when they are south at midnight, and in these circumstances the bright ones far outstrip the neighbouring stars in brilliance.

When Planets are Best Studied

The geometrical reason for this difference is clear. Only if a planet's orbit reaches out beyond the earth's can it ever be seen in the opposite direction from the sun. There is an important observational consequence of this fact. The outer planets can be studied at a time when the atmosphere is at its most tranquil, being least disturbed by convection currents from the ground. The inner planets, though they are nearer, can rarely be studied except against the background of a twilight sky, a circumstance that is even more serious for photographic than for visual observations.

There is a further distinction between the outer planets and the inner ones, which concerns their telescopic appearance. When an inferior planet is in line between the earth and the sun, it is at its closest, but it cannot be seen, for the same reason that the new moon cannot be seen: namely, that the sunlit surface is turned away from the earth. Near this position it is still practically at its closest but can be seen only as a thin crescent. In order to see the whole of its illuminated surface it must be studied when at its farthest, i.e when it appears smallest, and it is then so close to the sun as to be lost in its rays. This unfortunate state of affairs has no parallel with the superior planets. They are best studied at opposition, when they are high in a dark sky and when their apparent disks are largest.

They show no marked phases (though there is some noticeable "defect of illumination" of Mars, the closest superior planet, at certain points in its orbit), and when they are near conjunction with the sun, and therefore difficult to observe, they are uninteresting objects on account of the smallness of their disks. This combination of circumstances is partly responsible for the fact that less is known about the surface features of Venus, and particularly of Mercury, than about those of Mars, Jupiter, and Saturn.

LESSON 13

Mars as Revealed by the Telescope

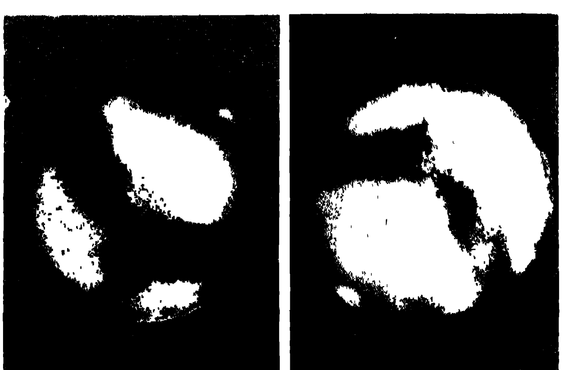
MARS, the fourth planet outwards from the sun, comes nearer to the earth than any of the planets except Venus. Its mean distance from the sun is 141,500,000 miles, but the eccentricity of its orbit (which amounts to 0·0933—greater than that of any other planet except Mercury and Pluto) causes its distance to vary to the extent of about 13,000,000 miles each way. At aphelion it is about 154,500,000 miles from the sun, at perihelion only 128,500,000 miles.

When Mars is in opposition, or nearest the earth, at about the time of perihelion, its distance from the earth is only approximately 34,637,000 miles; whereas when the opposition of Mars occurs when the planet is near aphelion, its distance from the earth may be as much as 62,680,000 miles.

The planet's sidereal period, which represents the Martian year, is 687 of our days, the inclination of its orbit to the ecliptic being only 1° 51′. Its synodic period is 780 days—the longest of any planet. The diameter of Mars is only about 4,230 miles; its surface is therefore little more than a quarter that of the earth, and its volume is rather less than one-seventh (0·150) the size of our world. Its mass amounts to 0·108 of that of the earth, its density is 0·72, and its surface gravity 0·38.

When Mars is studied through a telescope, certain details on its disk are seen to be present at the same hour for several evenings in succession, then they tend to drop backward, and vanish at the limb or edge of the planet's disk. Others are seen to appear at the western side, for Mars rotates from west to east, as does the earth. The cycle, as observed from the earth, occupies about 40 days. The length of day on Mars is 24 hours 37 minutes 23 seconds. The tilt of the axis of the planet is very little different from that of the earth, being about 24½ degrees to its original orbital plane. There is very little polar flattening perceptible.

In a sense more is known of this planet than of the moon, for both sides of its sphere can be seen and more complete views over its polar regions. The brilliant whiteness of these regions makes them a most striking feature; usually only one is present, according to whether the north or south pole is tilted toward the earth. The size of the polar caps varies with the Martian seasons, decreasing with the advance of spring and summer; the south polar cap occasionally vanishes altogether, as in 1894 and 1911. This seems to suggest that they are composed of frost or snow, and the fact that there is usually a darkening of the area encircling the pole immediately following the polar cap's diminution suggests the formation of water and flooding in consequence of the periodical melting of this not very thick frozen layer.



MARS. These photographs of Mars, taken by Dr. Hale at Mount Wilson Observatory, California, show the varying appearance of the planet on a single night in October 1909.

Geographical Features of Mars

Seen through the telescope when conditions for observation are good, what may be called the "geographical" features of Mars—permanent markings in grey-green or orange-brown—are revealed in impressive grandeur. The large orange-tinted masses which give Mars, as seen with the naked eye, its rosy hue, are believed to be desert areas. As regards the greenish-grey and bluish areas which cover about one-third of the planet's surface, the darkest portions, with sharply defined and permanent outlines, were once believed to be shallow water areas or seas.

The lighter greenish-grey regions vary considerably in colour and extent with the changes of the Martian seasons, e.g. the bright greenish tints of spring give place to yellowish and brown tones in the autumn. Areas thus appear and disappear amid the prevailing orange of the desert belts; where they are visible in these belts as greenish-grey spots, they are called oases and lakes, the latter being fairly permanent. It was believed that these regions were areas of vegetation, the changing tints representing the cycle of growth and decay through the long Martian year. The "seas" (Syrtis Major, Sinus Sabaeus, and Mare Acidalium or Mare Tyrrhenum) are always present, but they cannot be sheets of water or the atmosphere would contain more water vapour than it does.

All the definite features of Mars have been mapped and are generally known by the names given them by G. V. Schiaparelli (1835–1910), an Italian astronomer. There are also indefinite features—believed to be clouds of dust or sand—which temporarily obscure permanent areas by substituting a blurred patch, extending over the greater part of the planet's disk. Whitish areas that occasionally appear and disappear with the progress of the Martian day are ascribed to clouds of water droplets.

Mars has two moons, named Phobos and Deimos, discovered by Asaph Hall at Washington in August 1877. The outermost of these satellites, Deimos, is estimated to be only 5 miles in diameter; it revolves around Mars in 30 hours 18 minutes, at an average distance of 12,535 miles above the planet's surface. To an observer on Mars its disk would appear to be only 1/20th the width of our moon. Phobos, estimated to be about 10 miles in diameter, revolves in the short period of 7 hours 39 minutes, in an orbit which is only 3,715 miles above the planet's surface. Phobos and Deimos are the smallest satellites known.

It is a remarkable fact that Dean Swift in *Gulliver's Travels* (published 1726) states that the astronomers of Laputa "have likewise discovered two lesser stars or satellites, which revolve about Mars"—an anticipation of a scientific discovery that was not actually made until 150 years later.

Life on Mars?

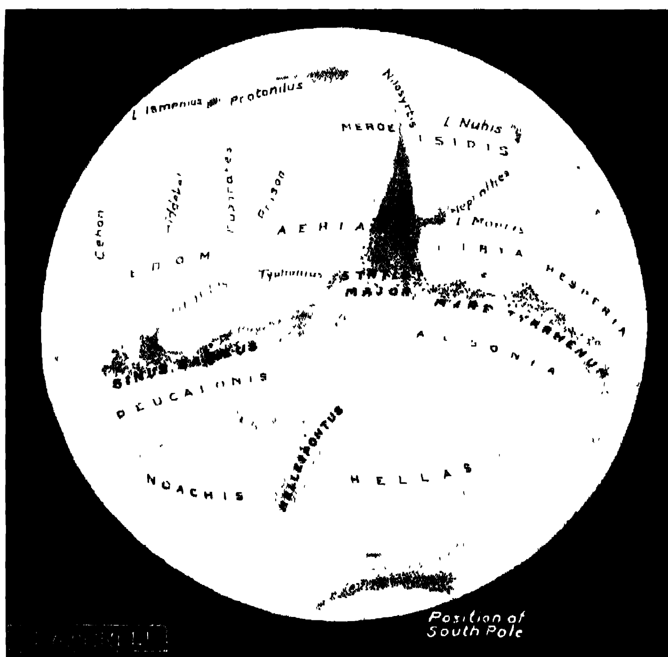
As to the possibility of life in other worlds, it is usual to look to Mars as offering the best opportunities for a solution of the problem. Its comparative proximity and the favourable conditions under which it can be observed suggest that it is on Mars that we should be able to recognize any signs of life.

Mars has water and an atmosphere, two essentials of life. The former has been proved to exist by spectroscopic analysis, although the amount of water in the atmosphere of Mars is apparently less than 0·15 per cent. of that existing in our atmosphere. This conclusion is in accord with the scarcity of clouds observed and the extreme rarity of the Martian atmosphere. As regards the latter, it contains no detectable oxygen but a large quantity of carbon dioxide. The planet's mass being relatively so small compared with the earth, its power to retain the atoms of the lighter gases would be much less and they would, in the course of ages, be lost in space.

A vitiated atmosphere may be plentiful, then, near the surface of Mars, even though water be scarce. That this is so is evidenced by the planet's shaded terminator—the line dividing night from day—seen when Mars is so placed in its orbit that its disk appears gibbous, like that of the moon two days from the full. On these occasions the terminator is not sharp and hard as is that of our moon, but softened, and it extends for some eight degrees in what is called the twilight arc beyond the true sunlit portion of Mars. This appearance is produced by the diffused and refracted sunlight in the planet's atmosphere, indicating that this is perhaps as much as half as dense as that of the earth. This is a very important point to establish in assessing the possibility of life on that small world.

Temperature and Atmosphere

Temperature is the next essential consideration, and here the evidence is not encouraging. As seen from Mars, the sun's disk appears, on average, rather less than five-eighths of its



MARS: SOME OF ITS PRINCIPAL FEATURES. Seen through a telescope, Mars presents a series of impressive geographical features—continents and "seas," desert areas, and regions believed by some observers to be covered with vegetation. All these phenomena have been mapped and are generally known by the names given them by the 19th-century Italian astronomer Schiaparelli, who was a pioneer observer of the surface of Mars.

width as seen from the earth ; while Mars receives, on average, only 0·43 of the light and heat received by our world. Its day differs but little from ours, but Mars experiences seasonal changes which are far more rigorous than those of the earth. These changes are particularly great in the southern hemisphere owing to the fact that when that half of the planet is tilted towards the sun, Mars is about 26,000,000 miles nearer than when its northern hemisphere is so turned. The same consideration applies to the earth, but only so as to cause the small difference of 3,000,000 miles.

The rarefied atmosphere of Mars is less able to retain through the Martian night the heat received by day ; this would result in intensely cold nights, unless the atmosphere be sufficiently dense near the surface to prevent rapid radiation. Radiometer tests have indicated that while the temperature may reach over 50 degrees Fahrenheit about midday in the equatorial regions, it drops to −112° F. at night, and is freezing at sunset, even in midsummer.

The Canals of Mars

Thus the conditions for life (as we know it) on Mars are not promising. Furthermore, the simultaneous presence of carbon dioxide and absence of oxygen makes it unlikely that there can be on Mars any plant life such as exists on the earth (other than, perhaps, some primitive form). As is generally known, green leaves containing chlorophyll have the power when they absorb carbon dioxide to break it up into its constituent elements under the action of sunlight, utilising the resulting carbon to build up their own tissues and returning gaseous oxygen to the atmosphere. This cannot be happening to any great extent on Mars. No trace exists in the infra-red spectrum of the planet of the characteristic bands due to the presence of chlorophyll.

What, then, of the visual evidences of vegetation and seasonal changes previously mentioned ? If not due to vegetation, how are these regular variations of tint and cycle of colour to be explained ? It seems most probable that they are due to seasonal changes in some primitive form of plant life not containing chlorophyll : such mosses and lichens abound on the earth in the arctic regions where temperature conditions most resemble those on Mars. This view is supported by the fact that the infra-red spectrum of the light reflected from the greenish areas of Mars matches exactly that of light reflected from terrestrial lichen. It is quite unlikely that any animal life (as we know it) can exist on Mars in the absence of oxygen, and with only moss as food.

The " canals " of Mars were first discovered in 1877 by Schiaparelli. They appeared to him as straight, greenish-grey streaks, very narrow and faint, extending across the reddish desert areas, and he called them " canali " (Italian for channels). They appeared to stretch from certain estuaries, bays, and " coast lines," as they might be called, to other similar markings and greenish-grey patches called oases and lakes (or lacus), where several canali were recorded as meeting and crossing. They extended in some instances for over 3,000 miles, and were singularly straight. In 1881 82, when Mars was again favourably placed for observation, Schiaparelli again saw the canali, and for considerable distances some of them appeared to be double. They seemed to develop rapidly with the progress of the Martian seasons, particularly during the spring.

Network of Straight Lines

Though many observers failed to perceive these markings, their existence was confirmed by numbers of expert astronomers who were suitably equipped with telescopes well placed for observation. Among these were W. H. Pickering and Percival Lowell in America, and Perrotin, Thollon, and Flammarion in France. In England, where conditions of observation are generally poor, the existence of the " canals " has been questioned.

According to Percival Lowell (1855 1916), who represented a very large number of expert observers, the " canals " appear as perfectly straight dark lines forming a network geometrically arranged over the reddish, and even crossing the dark greenish, regions of the planet's disk ; they are from 15 to 40 miles in width, and are up to 3,000 miles long ; as many as 14 such " canals " will meet at the oases and lakes and then continue across the apparent desert areas to other oases, or the extensive greenish-grey areas ; about 50 " canals " have been observed to be double, those constituting a pair being parallel and between 100 and 200 miles apart.

Cultivated Tracks

It is not claimed that the " canals " are really watercourses, but that they are irrigated areas —that they are apparently the resulting belts of vegetation which develop, most probably by cultivation, for several miles on each side of much narrower watercourses, which are artificially constructed to convey water from the polar regions when the snow cap begins to melt. This melting apparently floods the regions surrounding the poles ; and what more probable, therefore, than for reasoning beings to seek to make the best use of so valuable and rare a commodity as water ?

The geometrical arrangement of the cultivated tracks, so different from the courses rivers would take, strengthens the suggestion that the " canals " are the work of reasoning beings. Lowell, who had his observatory in the ideal

situation of Flagstaff, Arizona, delineated over 400 "canals" and some 200 "oases" and "lakes." Other astronomers have independently confirmed most of the discoveries of Schiaparelli and Lowell, both of whom prepared a chart upon which the details are mapped.

Clash of Opinions

The evidence against this theory and against the existence of life on Mars and the presence of belts of vegetation or "canals" is negative. Its chief exponents were Barnard in America, Antoniadi in France, and Spencer Jones in England. Barnard, though using the most powerful telescopes, claimed that he never saw what Lowell and so many others revealed; Antoniadi expressed like opinions; Spencer Jones gave his opinion as follows

"Lowell's theory involves many difficulties. If intelligent beings are at work in the way suggested, it would be expected that they would construct the canals to follow the contours of the planet's surface instead of making them absolutely straight for thousands of miles. Also, it is difficult to imagine that canals would be constructed to carry water from the melting north polar cap well down into the southern hemisphere, and from the south cap well into the northern hemisphere. The only portion of the theory which receives fairly general acceptance is the existence of seasonal changes on Mars which could reasonably be attributed to changes in vegetation."

Summing up, there is a definite clash among astronomers as to the meanings of the markings on Mars. The fact is that the "canals," if they exist, are at the threshold of visibility with existing means of observation; we shall make little progress in this matter until improved telescopes are available.

LESSON 14

Miniature Worlds of the Solar System

ONE of the results of Kepler's study of the heavens was the recognition of what seemed to be an arithmetical relation between the distances of the planets from the sun. This relation was worked out by the astronomer Titius, but it is generally ascribed to the German astronomer J. E. Bode (1747-1826). As subsequently amplified, it may be arrived at as follows.

First write down the numbers 0, 3, 6, 12, 24, 48, 96, 192, 384, and then add 4 to each. One then has 4, 7, 10, 16, 28, 52, 100, 196, 388; and these numbers are approximately proportional to the distances from the sun of Mercury, Venus, the earth, Mars, the asteroids, Jupiter, Saturn, Uranus, and Neptune. Thus if 10 is taken as the earth's distance from the sun, then the distance of Mercury is 4, that of Mars is 16, and so on. The actual distances, taking the earth as 10, are Mercury 3·9, Venus 7·2, the earth 10, Mars 15·2, the asteroids 27·4, Jupiter 52·9, Saturn 95·4, Uranus 192, Neptune 300. To this sequence the name of Bode's Law is given, although it should be realized that up to the present it is merely an empirical rule.

Discovery of the Asteroids

When it was first framed, the existence of the asteroids was unknown, and there was a gap between Mars and Jupiter. It was inferred that another planet must exist, corresponding to the number 28, and in 1800 various astronomers set to work to locate it.

On the night of January 1, 1801, the Italian astronomer Piazzi, at Palermo, discovered a hitherto unknown "star"; this was found to have a planetary orbit, and was named Ceres after the mythical divinity of Sicily. Its mean distance from the sun was found to be 257 million miles (28·1 on the Bode scale), and corresponded, therefore, very closely with the missing number. What was almost as astonishing was its exceeding smallness; later on, it was found to be only 477 miles in diameter.

Streaks on Photographic Plates

Then on March 28, 1802, another planet was discovered by Olbers, who named it Pallas; this was found to be at an average distance of about 256 million miles and to be only 304 miles in diameter. On September 2, 1804, Harding discovered Juno, a third small planet only 120 miles in diameter and at a mean distance of 248 million miles from the sun. Then on March 29, 1807, Olbers discovered yet another, which he named Vesta. This is only about 250 miles in diameter, and at a mean distance of 219 million miles from the sun.

Thus instead of the solitary planet whose existence had been suspected, there were found instead four small worlds. In 1845 another was found—Astraea, discovered by Hencke, in the same group. In 1847 three more were discovered. More have been added to the number every year—all of them much smaller than the first four discovered.

Since the application of photography to astronomical research large numbers of these asteroids have made their existence known by way of small streaks on photographic plates—their motion while the plate was being exposed causing them to be presented in this way instead of as dots, as are the "fixed" stars. Telescopically, they appear as small stars; hence their name asteroids, though planetoids or minor planets are more correct terms.

Altogether over 2,600 have been discovered; of these about 1,500 are permanently followed in recognized orbits. These have received names, chiefly from ancient mythology, together with numbers enclosed and prefixed to the name, thus: "(911) Agamemnon." A large proportion of the more recently discovered and very small planetoids are known at present only by numbers, and will not be named until their identity is established by successive revolutions.

Only about 20 of this host are estimated to have diameters exceeding 100 miles; probably about 150 have diameters between 50 and 100 miles; the remainder, judging from their relative faintness, are all below 50 miles in diameter. There are, in addition to these known planetoids with assigned orbits, a large number probably a thousand—whose identities are so involved with one another that they become difficult to follow. Averaging between 5 and 10 miles in diameter, they are very faint; and perturbations due to Jupiter's attraction still further complicate their orbits. There are many more that are less than 5 miles in diameter and beyond the range of telescopic photography.

Distance of Planetoids from the Sun

It might be supposed that from such numbers there might be sufficient material to form a planet at least as massive as the earth. This is far from being the case, for it is probable that the combined mass of all the planetoids known is between 1/500 and 1/1,000 of that of our world. At least 8,000 bodies similar to Ceres, the largest planetoid, would be required to constitute a world as massive as the earth. As the force of gravity and therefore the velocity of escape are so low on even the largest of the planetoids, it is certain that they can have no atmospheres such as we are familiar with.

Several planetoids show periodical variations of brightness, indicating that they rotate. They take between 1·75 and 13 7 years to complete their revolutions round the sun, both revolutions and rotations (where known) being direct, as in the case of the earth and planets in general. The inclinations of their orbits average within about 9 degrees of the ecliptic, thus conforming to that of the major planets. There are some notable exceptions, the chief being Hidalgo, which is 43 degrees, and Pallas, which is nearly 35 degrees, removed from the ecliptic.

The eccentricity of the planetoid orbits varies considerably, for while some are nearly circular, others are elongated ellipses with eccentricity amounting to 0·65 in the case of Hidalgo, 0 55 for Reinmuth's 1932 planetoid, and 0·54 for Albert. The range of some of the planetoids' distances from the sun is therefore very wide. About seven-eighths of them are from 215 million miles to 310 million miles from the sun. The remainder include Hidalgo, which has an aphelion distance of 880 million miles—as far as the orbit of Saturn—but its perihelion distance is only 185 million miles. Its revolution period, the longest of the planetoids, is 13 7 years.

Eros, which at aphelion is 165,630,000 miles from the sun, is only 105,230,000 miles distant at perihelion; hence it may approach to within 13,840,000 miles of the earth, and in January 1931 it actually came within 16,200,000 miles. Eros was then found to be an elongated body, suspected to be almost divided in the centre, irregular in form, and the two sections rotated about 4½ times in the course of a day. Its greatest diameter has been estimated to be between 15 and 20 miles. The period of its revolution is 643 days, but its synodic period is 845 days.

Four other planetoids have since been found to approach the earth still closer. Amor, with an orbit which also crosses that of Mars, was discovered by M. Delporte on March 12, 1932; it came within 10,160,000 miles of the earth on March 23, 1932. Amor appears to be only about 3 miles in diameter; its revolution period is 2·76 years. The minimum distance of Apollo, a tiny planetoid discovered by Herr Reinmuth in 1932, is 3,000,000 miles. Four years later Delporte discovered and named Adonis, which at its nearest is only 1,500,000 miles away. The smallest planetoid hitherto observed -it is probably less than one mile in diameter—has approached nearer to the earth than any other celestial body except the moon.

Now called Hermes, it was accidentally discovered by Reinmuth on October 28, 1937; two days later it was only 485,000 miles away, missing a collision with the earth by 5½ hours. It is possible for this planetoid to approach within 220,000 miles of the earth, which is less than the mean distance of the moon; its revolution period is rather more than 2 years.

Origin of Planetoids

What of the origin of the planetoids? Are they, as has been suggested, fragments of an exploded world? Although they occupy such a wide belt between the orbits of Mars and Jupiter—and even beyond—it can be shown that this could have been produced by the gravitational action of the planets, more particularly Jupiter. A remarkable circumstance is that all their orbits are so involved that it is not possible to disentangle one from the rest without breaking through others.

It has been possible to show that the centres of the orbits of certain planetoids all coincide with a point on a line which joins the sun with the *centre* of Jupiter's orbit. Thus there is evidence for the conclusion that some planetoids once occupied a certain spot at a certain epoch, when they would have constituted a single world, instead of being, as now, fragments possibly of a world that met with catastrophe.

LESSON 15

Jupiter and its Many Moons

THE greatest of the planets is Jupiter. Thirteen hundred and twelve times the size of the earth, it has an immense mass, 318·4 times that of the earth and more than twice the amount of all the other planets put together. With the exception of Venus, it is usually the brightest planet in our sky, and with its 11 satellites Jupiter forms a miniature solar system of its own.

Its mean diameter is given as 85,750 miles, but the planet is so elliptical that its polar diameter is 82,800 miles and its equatorial diameter is about 88,700. It is thus an oblate spheroid with a great equatorial bulge, and it has a surface about 119 times greater than that of the earth. Its density is only 0·24 that of our world and 1·34 times that of water ; this indicates that Jupiter is very largely composed of gases, which descend doubtless for many thousands of miles below its visible surface as a colossal atmospheric envelope.

While the force of gravity on Jupiter *averages* about 2·65 times that of the earth, it varies considerably between the equator and the poles, the weight of bodies becoming greater as the poles are approached ; superficial gravity, which is 2·64 at the equator, amounts to 2·67 at the poles of the planet. This is due in part to polar flattening and in part to rapid rotation of the equatorial regions.

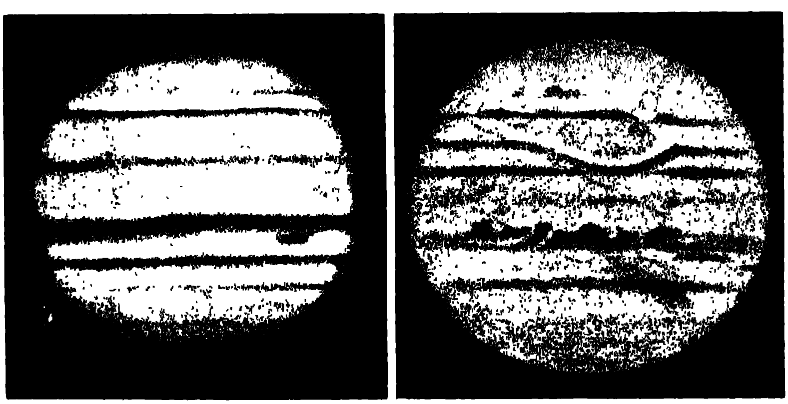
Rotation Periods

Jupiter's rotation periods are remarkable. Not only does it rotate faster than any other planet, but at rates which vary for different latitudes and even for different objects at the same latitude. At the equatorial belt, averaging about 12,000 miles in width, the speed amounts to a mean of 9 hours 50 minutes to complete a rotation ; this is called System I. In temperate latitudes the speed averages about 9 hours 55 minutes ; this is System II. In high latitudes the speed of rotation amounts to about 9 hours 57 minutes. Thus there is a difference of seven minutes, or approximately 1/85th of the entire period ; in the course of 85 complete revolutions of the planet, therefore, the equatorial regions must gain a complete rotation on the rest of Jupiter's surface.

Without Appreciable Seasons

Since the equatorial circumference is about 300,000 miles, objects at or near Jupiter's equator travel at the rate of some 30,000 miles an hour, and 350 miles an hour faster —more or less according to latitude— than in the north and south temperate zones. This can be compared with the speed of nearly 1,000 miles an hour at which bodies travel in terrestrial equatorial regions. Jupiter rotates in an almost upright position, because the inclination of its axis to the plane of its orbit is only 3 ; it can have no appreciable seasons due to varying tilt relative to the sun.

Jupiter revolves at an average distance from the sun of 5·20 astronomical units, i.e. 483,300,000 miles ; but this is subject to wide variation, owing to the great eccentricity of the planet's orbit, which amounts to one-twentieth. Therefore while Jupiter is about 507,000,000 miles from the sun at aphelion, it is only about 460,000,000 miles away at perihelion. This makes a considerable difference in the apparent size and brightness of the planet as seen from the earth ; for when Jupiter is in opposition and at perihelion, i.e. in October, it is then only about 367,000,000 miles away and has an apparent diameter of about 50 seconds of arc. When opposition occurs at aphelion, i.e. in April, then Jupiter is about 414,000,000 miles distant and has an apparent diameter of 44 seconds



JUPITER'S SURFACE FEATURES. This planet is remarkable for its constantly changing " belts," and spots. They vary in width, depth, and tint, and these drawings, made by members of the British Astronomical Association, show some of these differences of appearance. The first (left) records the surface of the planet on January 10, 1930. The one on the right, on January 20, 1931, shows considerable variation.

of arc. It takes Jupiter 11 years, 314 days to complete one sidereal revolution ; about six years intervene between aphelion and perihelion.

The details on Jupiter's disk are varied, distinctly visible, and subject to constant change. Even a small telescope of 2-inch aperture will reveal two or three of the chief belts. The general arrangement of these belts is more or less uniform in character, but they change both in width and depth of tint in the course of Jupiter's long year. With the aid of powerful instruments a mass of detail can be determined —the great reddish tropical belts bordering the bright yellowish equatorial band, while greyish and greenish belts indicate the temperate regions. Spots—some very bright, others dark —appear on these belts and change their positions relative to one another from time to time.

The Great Red Spot

The most remarkable of these spots is the Great Red Spot, which first became prominent in 1878 below the South Tropical Belt. It was calculated to be about 30,000 miles long, parallel to the belt, and 7,000 miles wide. Originally pinkish in tint, it became a deep red by the next year ; it has been getting fainter and rounder, until now it is scarcely perceptible. But the great bay or hollow, 45,000 miles long, which it occupied still remains a very distinct feature of the South Tropical Belt and one of the most permanent markings on the planet ; it is called the South Tropical Disturbance.

The Great Red Spot cannot be attached to the planet's surface, because it travels at a different rate from that of the adjoining belts and appears to be floating, together with the belts and other details, in the atmosphere of Jupiter. The continual and rapid changes in the other surface details indicate that they are produced by currents and storms in a dense atmosphere, only the upper layers of which are ordinarily observable. It was once thought that thousands of miles below them is the actual and largely molten surface of the planet, at a terrific heat consistent with its low density and disturbed state.

This view, based upon the observed phenomena and the analogy of the earth, was held until it was found that the cloud surface of Jupiter averaged some 200 F. below zero. This appeared to rule out the possibility of the clouds being composed of water vapour. Then analysis of Jupiter's spectrum indicated the presence of ammonia and methane in its atmosphere, and therefore that the clouds might be composed of solid ammonia crystals. This is consistent with the theory of Sir Harold Jeffreys (b. 1891), derived from the extreme lightness of Jupiter as compared with its bulk or volume, which postulates that Jupiter has a solid core approximately 42,000 miles in diameter.

Above this is an ice-layer some 16,000 miles thick, and enclosing the whole is the dense and very cold cloud-laden atmosphere about 6,000 miles in depth. This theory has obtained some support from the discovery of ammonia and methane in Jupiter's atmosphere, as regards frigid conditions ; otherwise there is actually little evidence for Jeffreys' supposition of Jupiter's internal ice and rocky core. There is no probability of life on such a world, any more than on a molten one.

Eleven Satellites

Jupiter has 11 satellites. The four largest were first discerned by Galileo in January 1610, and they are called the Galilean Moons. They have also individual names, but as a rule they, together with Jupiter's other satellites, are known by Roman numerals.

The first eight of these satellites revolve direct from west to east, but the motion of the three outermost is retrograde, i.e. clockwise. Until 1892 Jupiter was believed to have only four moons. No. V was discovered by Barnard at the Lick Observatory in 1892. In 1904 Perrine discovered VI by photography at the same observatory, and VII in 1905. Then VIII was discovered by Melotte in 1908, and IX in 1914 by Nicholson, who also discovered X and XI in 1939.

Very little is known about these small bodies. In view of the great eccentricity of the orbits of the five outermost, their considerable inclination from the plane of Jupiter's orbit, and also of the fact that three of the satellites have a retrograde motion, it seems probable that they are " captured " planetoids.

The four large Galilean moons would be perceptible to the naked eye were it not for their apparent close proximity to the radiant

MOONS OR SATELLITES OF JUPITER

Satellite	*Diameter*	*Mean distance from Jupiter*	*Sidereal Period of Revolution*		
	miles	miles	days	hours	mins
V ..	100	112,500	–	11	57
	(about)				
I Io . .	2,470	261,000	1	18	28
II Europa	2,060	415 000	3	13	14
III Ganymede	3,580	664,000	7	3	43
IV Callisto .	3,360	1,167,000	16	16	32
VI ..	130	7,113,000	251	-	-
	(about)				
VII . .	40	7,290,000	260	—	—
	(about)				
X ..	20	7,300,000	260	—	—
XI	20	14,000,000	692	—	—
VIII	25	14,600,000	738	21	36
	(about)				
IX . ..	11–17	14,690,000	745	(about)	

Jupiter. As it is, Ganymede and Callisto may be observed with good field glasses, appearing, at times, about one-twelfth and one-sixth of a degree respectively either to the right or the left of the planet. (A degree, it should be explained, is approximately twice our moon's apparent width.)

Observed through powerful telescopes, these satellites present perceptible disks with distinct markings sufficient to indicate that each satellite keeps the same face turned towards Jupiter. The changes in their relative positions, and more particularly their eclipse and transit phenomena, provide constant entertainment to possessors of smaller telescopes. These changes occur several times a week, the orbits of the satellites being so nearly in the plane of Jupiter's equator that they all, except Callisto, pass through the planet's shadow and are eclipsed or occulted at every revolution. When they pass between us and Jupiter, they are seen to travel in transit across the disk. The times of these occurrences are known to-day with great precision, but in the 17th century it was found that they seldom took place at the expected time—they were either too early or too late, the difference often amounting to several minutes. Then in 1675, Roemer (1644-1710), a Danish astronomer, explained the discrepancies as being due to the time light takes to travel across the space between us and the satellites. As previously stated, this distance varies, and Jupiter is at times over 200 million miles nearer than at other times; as the distance of Jupiter increases so the satellite phenomena appear delayed, the reverse occurring as Jupiter draws nearer. It is now known that light travels at the rate of 186,325 miles per second, but Roemer's explanation was not accepted for more than fifty years, until it was confirmed by Bradley's discovery of the aberration of light.

LESSON 16

Saturn and its System of Rings

Saturn, the second largest of the planets, is the most impressive of them, on account of the ring system which encircles the planet; this is seen from year to year at a different angle, and so provides an ever-varying spectacle. While the sphere of Saturn is 95·2 times more massive than the earth, it is 763 times the size or volume; this indicates how exceedingly light in density the planet must be. Its density is only 0·12 that of the earth and 0·69 that of water. Assuming Saturn to be of equal density throughout, it would float on water.

Immensely Long Seasons

The planet's mean diameter is 73,000 miles, but owing to its great oblateness or polar flattening it is more elliptical than any other planet. This amounts to about 10 per cent.; so while its equatorial diameter is 74,900 miles, its polar diameter amounts to only 67,700 miles. As a result of this difference, bodies would weigh about 30 per cent. less at the equatorial regions of Saturn, as compared with the polar.

This oval shape of the planet is very obvious when the rings are presented edgewise and therefore almost invisible. This equatorial bulge, amounting to nearly 4,000 miles, is due to Saturn's very rapid rotation, which takes only 10 hours 14 minutes 24 seconds at the planet's equatorial regions, and from 20 to 25 minutes longer in the belts to the north and south. In this respect Saturn resembles Jupiter and also the sun.

Because the axis of the planet is inclined 26° 45′ to the plane of its orbit, it has well defined seasons, but of immense length, the sidereal period of its revolution being 29 years 167 days. A season on Saturn is between 7 and 8 of our years in length. Saturn revolves at an average distance from the sun of 9·54 astronomical units, or 886,000,000 miles; but as the eccentricity of its orbit amounts to 0·056, the planet's distance varies between 936,000,000 miles at aphelion and 836,000,000 at perihelion. Therefore, while Saturn may approach the earth to within 745,000,000 miles at its nearest opposition, it will be only about 100 million miles farther off at an aphelion opposition; consequently there is not a great variation in the apparent brightness of Saturn.

Clouds of Vapour

The planet's sphere, which, like Jupiter and the sun, appears brightest in the centre and fades off round the edges, has a high albedo, amounting to 0·42. It is crossed by several belts, faint replicas of those of Jupiter, with the broad equatorial belt a brilliant yellow, the tropical and temperate belts greyish, and the polar caps of a greenish tint. On the belts appear occasionally white or dark spots, together with faint, indistinct shadings.

These belts represent clouds of vapour in an atmosphere of great depth, doubtless of many thousands of miles, the rapid rotation at different rates spreading the clouds out into belts which rush past one another at great speeds. A difference of over 750 miles an hour

SATURN AND ITS RINGS. Discovered by Galileo in 1610, the ring system of Saturn was thought to be a solid body or bodies, but it is now known to be composed of an aggregation of small moonlets revolving about the planet with great rapidity.

exists between the speed of the equatorial belt and those of more temperate latitudes.

It has hitherto been considered probable that several thousands of miles beneath this visible cloud-laden surface a hot and possibly molten surface existed. Various considerations warranted this conclusion, notwithstanding the lack of solar heat. In recent years theories propounded by Sir Harold Jeffreys have credited Saturn not only with an intensely cold atmosphere but also with an average depth of some 16,000 miles, enveloping a world covered with ice to a depth of 6,000 miles, this in turn enclosing a solid rocky core approximately 28,000 miles in diameter.

This theoretical presentation is highly speculative ; but, as in the case of Jupiter, it has obtained some credence because the atmosphere of Saturn has been found to have a large proportion of methane and a relatively smaller proportion of ammonia, as compared with Jupiter, this being attributed to the much greater cold experienced by Saturn owing to its much greater distance from the sun.

Saturn's ring system is unique and, when wide open, exhibits a large area of the surfaces of the rings. It adds about one and two-thirds times to the brilliance of Saturn observed with the naked eye. In 1936 the rings almost vanished ; then they began to open out, to reach their widest in July 1943. After that they began to close up until in 1950 they almost vanished again. During this time it was the south side of the rings that was presented to view.

The successive phases they go through are indicated in the illustration on this page, the dark equatorial band shown in the 1921 picture being the shadow produced by the invisible rings on the planet's surface. At intervals of nearly 15 years the rings go through all their phases, but alternately in the reverse direction presenting the north and then the south side of the rings to our view.

When at their maximum, they extend a little above the globe of the planet and have an apparent diameter about one-sixth more than Saturn. Just before vanishing, the rings appear as a thin line of light projecting from each side of the planet's disk. When the rings are presented quite edgewise, they entirely vanish, and in their place are a string of dots and streaks, suggesting that the rings are not more than 50 miles in thickness.

Composition of the Rings

In extent the rings are enormous, resembling vast concentric disks, the outer one with a diameter of 171,500 miles. There are three main divisions of the ring system, known as A, B, and C. The outer ring A, less bright and distinct, is about 10,000 miles wide. This is separated from B, which is much the brightest ring, by Cassini's division, which is between 2,000 and 3,000 miles in width. The ring B is about 16,000 miles wide, and has a diameter averaging 145,000 miles. These rings vary in width, together with the divisions between them, on account of perturbations caused by Saturn's satellites, to which are doubtless due the additional divisions occasionally seen, the ring A being sometimes divided by what is known as Encke's division.

Inside the bright ring B is a division probably about 1,000 miles wide, separating it from the inner ring C, which is very faint and dusky. C is usually called the "crape" ring, and is about 11,000 miles in width, the indistinct inner edge being between 6,000 and 7,000 miles from the planet's surface. While the rings produce a shadow upon the planet, the globe of Saturn also casts a very dark shadow over the rings.

The rings of Saturn have been proved to be composed of innumerable particles in steady but very rapid rotation round Saturn—" moonlets," they might be called—each with its own orbit and travelling in the same direction, that is, counter-clockwise, and almost in the same plane as the chief satellites. A few of these particles

may approach 50 miles in diameter, judging by the appearance of the rings when seen edgewise, but the great majority must be of small dimensions, perhaps no larger than golf balls, or small shot, because the total mass appears to be less than a quarter the mass of our moon.

They revolve round Saturn at about 10 miles a second on the outer edge of the ring system, a particle taking nearly 140 hours to complete a revolution round that edge of the system. At the inner edge they attain a speed of 12½ miles a second, and so complete their revolution on this smaller circumference in about five hours.

In 1857 James Clerk Maxwell (1831–79) had shown from theoretical considerations that the rings must be composed of separate particles like swarms of meteorites. The fact that the planet and some of Saturn's satellites could be seen through the less dense parts of the rings confirmed this. Then in 1895, J. E. Keeler (1857–1900) proved conclusively by spectroscopic observation that the inner portions travelled faster than the outer, and exactly as they would if they were composed of particles, their light and other considerations leaving no doubt in the matter. It is possible that they are the fragments of a satellite which approached the planet so closely as to be broken up by tidal forces. Saturn's satellites number nine. Their chief details are given in the table.

SATELLITES OF SATURN

Satellite	*Diameter in miles*	*Mean Distance from Saturn*	*Sidereal Period of Revolution*		
	(about)	miles	days	hours	mins.
Mimas	370	115,300	—	22	37
Enceladus	460	148,000	1	8	53
Tethys	750	184,000	1	21	18
Dione	900	235,000	2	17	41
Rhea	1,150	327,500	4	12	25
Titan	3,550	760,000	15	22	41
Hyperion	300	920,000	21	6	38
Iapetus	1,000	2,220,000	79	7	56
Phoebe	200	7,996,000	550	10	35

Titan, first observed by Christian Huygens (1629–95) in 1665, has a diameter greater than that of the planet Mercury, and appears to be the largest satellite in the solar system. It is above ninth magnitude, and can be seen with small telescopes of 2 to 3 inches aperture; in large instruments it shows a disk with periodic variations in brilliance. Its mass is greater in proportion than that of our moon and about 3½ times that of water, so Titan seems to be also the most massive of all the satellites of the solar system, so far as is known. It is also unique amongst satellites in that it has an atmosphere, chiefly of methane, like Saturn itself.

The Same Face toward Saturn

Tethys, Dione, Rhea, and Iapetus were discovered by J. D. Cassini (1625–1712). The densities of the first three are very low, while their albedo is high, suggesting a gaseous condition quite unlike Titan. Mimas and Enceladus, discovered by Sir William Herschel (1738–1822) in 1789, are the lightest in density, Mimas being over two thousand times less than the moon; it may be nothing but a mass of ice. Hyperion, discovered by W. C. Bond (1789–1859) in 1848, has also a very low density. Phoebe was found photographically by W. H. Pickering (1858–1935) in 1898, and is remarkable as being the only one with a retrograde motion round Saturn; this, together with its great eccentricity of 0·166 and great inclination of about 149° to the planet's equator, suggests that the satellite is a "captured" planetoid.

The fact that sunlight is 90 times less (1/90) per unit area at the distance of Saturn, as compared with the earth, renders the satellites rather faint objects; but regular variation in their brightness is perceptible, and from this it appears that they keep the same face toward Saturn, as does our moon to the earth.

LESSON 17

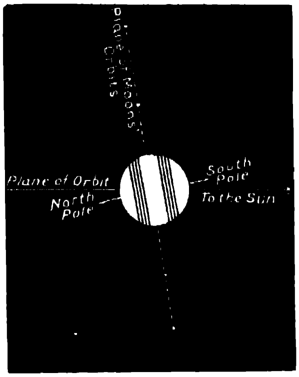
Uranus, the Green Planet

URANUS, the next planet beyond Saturn, is about twice as far from the earth, and presents therefore a much smaller disk and with very little detail perceptible. It was the first additional world to be discovered, and it led directly to the finding of Neptune. The discovery of Uranus was made by Sir William Herschel on March 13, 1781, with the 7-inch reflector telescope which he had made himself.

At first the new body was regarded as a tailless comet, but by the following year it was found to be a planet moving in an orbit quite unlike that of a comet. J. Lalande (1732–1807) and other Continental astronomers gave it the name of Herschel; later Bode named it Uranus after the father of Saturn in Greek mythology. This gradually displaced the other name.

By referring to old star catalogues and previous observations, it was found that Uranus had been recorded many times as a star, including an observation recorded by John Flamsteed (1646–1719), the first astronomer royal, in 1690. Uranus appears as a star of the sixth

magnitude, and is just discernible to the naked eye, a good telescope being required to show its planetary disk. It may seem surprising that the ancient astronomers had not noticed Uranus in the clear air of Egypt and Chaldea, but the apparent movements of this planet are so slow, taking 84 years and six days to complete a circuit of the heavens (this being the planet's year), that its daily motion would escape notice.



SYSTEM OF URANUS, showing the singular angles of the equatorial belts, planes of orbits, and the positions of the poles.

The mean distance of Uranus from the sun is 1,783,000,000 miles; but the eccentricity of its orbit being 0·047, its actual distance varies between about 1,866,000,000 when at aphelion and 1,698,000,000 at perihelion. Consequently there is very little difference in its apparent brightness or size as seen from the earth, its angular diameter averaging about 3·75″ (seconds of arc) and attaining about 4″ when at its nearest.

Uranus is 59 times the size of the earth, but, though so much greater in volume, Uranus is only 14·6 times the mass; consequently its density is only 0 25 that of the earth or 1·36 times that of water. It therefore resembles Saturn and Jupiter in density, and also in having a very deep gaseous envelope. The mean diameter of Uranus, according to the outer cloud surface of this atmospheric envelope, is about 31,900 miles; but, as in the case of Saturn and Jupiter, its polar diameter is much less than the equatorial, amounting to about 1/14 less. The planet's ellipticity indicates a very rapid rotation, which amounts to only 10 hours 49 minutes; this represents the length of a Uranian day, except so far as the days are abnormally lengthened by the planet's remarkable arrangement of seasons.

Angle of Rotation

Uranus rotates at the surprising angle of about 98 degrees to the plane of the planet's orbit. At this angle the greater part of the northern hemisphere and, alternately, the southern would remain continuously in the sunlight for 21 years; this is the length of a season on Uranus, and a winter night of similar length would be experienced. But the sun appears at that distance only as a very bright star with a scarcely perceptible disk and with a surface 368 times less, so Uranus must receive 368 times less light and heat than the earth, area for area. Thus twilight conditions must prevail on Uranus, providing that this feeble sunlight can penetrate the planet's dense cloud canopy. The spectrum of Uranus, while consisting of reflected sunlight, contains absorption bands indicating a still greater quantity of methane than in the case of Jupiter and Saturn. These bands abstract so much of the orange and red light reflected from the planet that, like Neptune, it appears greenish in the telescope.

The surface of Uranus shows belts similar to those of Saturn, but much fainter and tilted at the remarkable angle that is almost perpendicular to the plane of the planet's orbit. This orbit has an inclination of only 46′ (minutes of arc) to the plane of the earth's orbit, and is therefore about the same. The albedo of Uranus is high, amounting to 0 60, as would be expected from a cloud-laden atmosphere of great reflecting power.

Extremely Faint Satellites

Uranus has five satellites, their chief details being shown in the accompanying table. They are all extremely faint. Titania and Oberon, appearing about 14½ magnitude, were discovered by Herschel in 1787. Ariel, about 16 magnitude, and Umbriel, about 16½ magnitude, were discovered by W. Lassell (1799-1880) in 1851. Miranda, at 17 magnitude, was discovered by Kuiper in 1948. The most remarkable features about these satellites are that they all appear to travel in a retrograde direction round Uranus (that is, clockwise), a motion that is shared by the rotation of the planet itself, which is also retrograde; also that the orbits of these satellites are at an extreme angle to the plane of the planet's orbit. This amounts apparently to 82° (degrees of arc), but is actually 180° – 82° = 98° when the retrograde motion is taken into account.

These point to the conclusion that Uranus at some far-distant epoch turned over to this angle of 98° together with its satellites, or while the whole was in a gaseous state and before the birth of the satellites; for since the planet rotates in the same plane and direction as the

SATELLITES OF URANUS

Name	*Diameter in miles*	*Mean Distance from Uranus*	*Sidereal Period of Revolution*		
	(about)	miles	days	hours	mins.
Miranda	100	81,000	1	9	56
Ariel	300	120,000	2	12	29
Umbriel	250	167,000	4	3	28
Titania	600	273,000	8	16	56
Oberon	550	365,000	13	11	7

satellites, the inverting process must have been common to both. The most probable cause would appear to have been the near approach of some big body--another sun perhaps--which, by raising great tides on the plastic and possibly half-formed world of Uranus, was thus able to alter its axis of rotation long before the satellites came into existence.

Uranus is so distant that it remains in each sign of the zodiac for seven years, since the planet's annual motion through the heavens amounts to an average of only 4½ degrees, though it is travelling at about 4¼ miles a second. The physical condition of the planet is generally regarded as being similar to that of Jupiter and Saturn, the actual surface being some thousands of miles below its atmospheric cloud surface. It may be at a great heat—probably molten, more or less—notwithstanding what must be a very frigid exterior. Nevertheless the possibility of a frigid and solid interior similar to those suggested for Jupiter and Saturn (*see* Lessons 15 and 16) would also apply to the planet Uranus.

LESSON 18

Discovery of Neptune and Pluto

NEPTUNE, for long regarded as the outermost planet of the solar system, is not visible to the naked eye, though it may be glimpsed with powerful field-glasses. Its discovery in 1846 was the result of one of the greatest triumphs of mathematical astronomy. The existence of a world beyond Uranus had been suspected as the cause of certain accelerations and retardations in its orbit, which amounted to nearly two minutes of arc. While Saturn and Jupiter accounted for part of this irregularity, the residue was suggested by the German astronomer F. W. Bessel (1784–1846) as due to a planet beyond Uranus.

Search for a New Planet

Then in 1845 the English astronomer J. C. Adams (1819–92) and in 1846 the French astronomer U. J. Leverrier (1811–77) independently calculated where this supposed planet must be. Though Adams had computed the position first and informed the astronomer royal by letter, his communication was neglected, and he thus lost the honour of the discovery. It was not until July 19, 1846, that J. Challis (1803–82) of the Cambridge University observatory, took up the search at the suggestion of G. B. Airy (1801–92), the astronomer royal, as Leverrier's results had now been made known.

In August 1846 Leverrier's elements of the planet's position, which were in accord with those already computed by Adams, were published. Subsequently Leverrier wrote to the observatory at Berlin, on September 18, asking them to search for a " new planet looking like a star of the ninth magnitude and having a perceptible disk," indicating also where it was to be found. It was discovered within half an hour, and only 52 minutes of arc from the place predicted ; it had the apparent disk but was a magnitude brighter. This was a great achievement for Leverrier, and one in which Adams shares the honour, though at the time it caused much controversy, for Professor Challis at Cambridge had actually observed the planet weeks before, but in the absence of good star-charts had failed to identify its true nature.

Neptune's mean distance from the sun is 30·06 astronomical units ; from this it departs relatively little, being at aphelion 2,816,000,000 miles, and at perihelion 2,768,000,000 miles, from the sun. The eccentricity of Neptune's orbit is only 0·0086, and its orbit the most circular of all the planets, except that of Venus.

The inclination of its orbit to the ecliptic is only 1° 47′.

While the mass of Neptune is 17 times that of the earth, its size or volume is 43 times ; therefore the planet's density is much less, being 0·40 that of the earth or 2·22 that of water. Neptune is therefore but little denser than Uranus, and is generally a replica of that planet, except that it exists under much more frigid conditions as regards solar heat. The sun would appear as a very bright star, and to the unaided eye would show no perceptible disk. The heat and light received by Neptune are 900 times less, area for area, than are received by the earth ; although this solar light would far exceed our brightest moonlight, Neptune is a world of twilight.

Seasons 41 Earth-years Long

It rotates very rapidly, in about 15 hours 40 minutes, on an axis inclined about 61 degrees to the planet's orbit. Because it takes 164 years 280 days to complete a revolution round the sun, Neptune has very pronounced seasons of great length, amounting to about 41 of our years.

Telescopically, Neptune's disk appears to have an average diameter of only 2·0 seconds of arc. From this its real diameter has been calculated to be about 27,800 miles. Neptune has the high albedo of 0·52, indicating a cloud-covered surface. This, as in the case of Uranus, appears greenish, but without trace of belts or markings, the details so far ascertained being revealed spectroscopically. These indicate a

very dense and deep atmosphere, and while its surface may be 220 degrees below zero (Centigrade), yet great heat possibly exists in its depths, where, however, neither sunlight nor solar heat may ever penetrate; or frigid conditions may exist similar to those now suggested for Jupiter, Saturn, and Uranus.

Neptune's Larger Satellite

Triton, the larger satellite of Neptune, revolves in a period of 5 days 21 hours 2¾ minutes, at an average distance of 220,000 miles from Neptune's centre, and so almost as far as the moon is from the earth. Its orbit is retrograde and inclined at between 35° and 40° to that of Neptune. It appears to have the remarkable property of a varying angle of inclination, which has been found to change in the course of many years to the extent of about 10°; this deflection of the path of the satellite has been ascribed to variations in the plane of Neptune's equator. Triton was discovered by Lassell in 1846. It is very faint, appearing about 13th magnitude, and is therefore estimated to be approximately the size of our moon. A second satellite, Nereid, was discovered by Kuiper in 1949.

Since the discovery of Neptune the existence of yet another world beyond this planet had been suspected for many years. Further unaccounted perturbations of Uranus, together with the fact that the aphelia of several comets might therefore be accounted for, stimulated the search by methods similar to those of Adams and Leverrier. The existence of "families" of comets had long been regarded as indicating worlds beyond Neptune, because, while the comets had the sun at the perihelion end of their very elliptical orbits, they had one of the greater planets near the aphelion end. Because certain comets had their aphelia far beyond the orbit of Neptune, these were regarded as pointing to trans-Neptunian planets, but they supplied no further data.

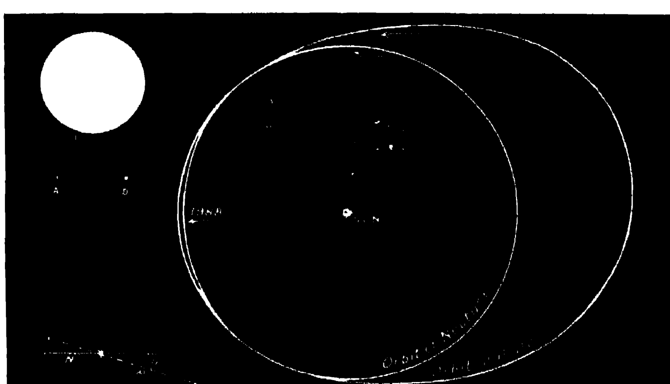
Trans-Neptunian World

More definite were the small irregularities in the motion of Uranus, Neptune, and even Saturn, which could not otherwise be accounted for. Dr. Percival Lowell, W. H. Pickering, and A. Gaillot, in particular, made elaborate mathematical calculations to locate the trans-Neptunian world which they firmly believed existed. An immense amount of work was involved in these, Percival Lowell publishing his *Memoir on Trans-Neptunian Planet* in 1915. This indicated the region where the body, which he termed Planet X, would be found. Pickering also published his estimate of the approximate position of this unknown world in 1919. Though an intermittent search was maintained after Lowell's death in 1916, it was not until January 21, 1930, that the suspected planet was discovered. It had been the rule at the Lowell observatory at Flagstaff, Arizona, to photograph those regions in some part of which, according to Lowell's elements, the planet might be situated, and then to scrutinize the plates to find any small dash in place of the multitude of dots which represented the so-called fixed stars.

Pluto's Approach to the Earth

It was thus that the young assistant at the observatory, Clive W. Tombaugh (b. 1906), discovered the world beyond Neptune on one of the photographic plates. Dr. V. M. Slipher, chief of the observatory, closely studied the moving body; elements were calculated, and on March 13 the official announcement was made that the trans-Neptunian planet was actually discovered only 6 degrees away from the place assigned to it 15 years earlier by Lowell's elements. It was subsequently found that Pickering's predicted position was only about 10 degrees from where the planet was found, while some of his figures relating to it were closer than Lowell's.

In 1950 the 200-in. telescope showed Pluto to be about half the diameter of the earth, or 4,000 miles, the period of its revolution round the sun being 248 years. Its orbit is the most elliptical of all the planets, ranging from about 50 astronomical units in aphelion, that is, 4,650,000,000 miles, to 29·6 units, or 2,753,000,000 miles, at perihelion. It comes within the orbit of Neptune, but at the high inclination of its plane of 17 degrees to the



ORBITS OF PLUTO and Neptune. Date 1988 represents next perihelion of Pluto. Top left, sun as seen from the earth A, as seen from Pluto at aphelion; B, at perihelion. Bottom left: N, diameter of Neptune's orbit; P, greatest diameter of Pluto's orbit; I, inclination of Pluto's orbit to Neptune's.

ecliptic, so Neptune and Pluto can never meet. At present Pluto is at a distance of about 3,300,000,000 miles, and it is gradually coming closer to us each year. Sunlight is there little more than our moonlight, and Pluto at present receives about 1,500 times less heat and light from the sun than the earth does. So small a planet as Pluto can hardly have a mass greater than a tenth that of the earth; if that be so, its effect on Uranus is too small to be detected. In a sense, then, the discovery of Pluto was a coincidence. Nevertheless, if no prediction had been made, no search would have been made, and it is fitting that the discovery should have been made at the observatory founded by the astronomer who made the prediction.

LESSON 19

The Three Classes of Comets

The name comet is derived from the Greek *komētēs*, long-haired, a word that had its origin in the hairy appearance of the luminous mist which surrounds the celestial body called a comet and which, in many, trails away into space; this appearance forms the so-called tail, and obtained for comets their old title of *stella comatae*, that is, "hairy stars." Over 1,000 comets are known, the elements of whose orbits have been computed; on average, about five new ones are discovered each year. The greatest number observed in one year is thirteen in 1932, and again in 1947 and 1948.

The majority of comets have never been seen without telescopic aid; as a rule, not more than about one in ten becomes easily visible to the naked eye. Occasionally a splendid body appears, with a nucleus that may be as bright as Venus and with a tail that stretches half way from the horizon to the sky overhead; but only about five of these comets may be expected on an average in a century.

Return to the Sun

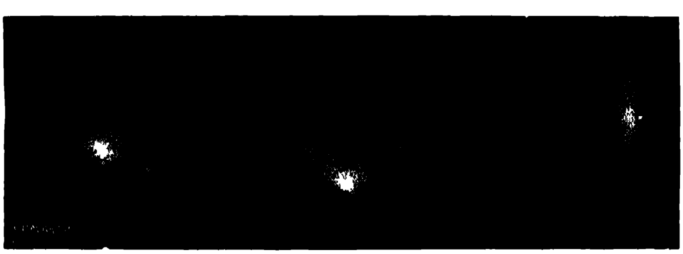
While a comet usually has a bright central nucleus or a perceptible condensation surrounded by a more or less spherical mass of fainter luminosity, called the coma, the radiant tail is frequently imperceptible or absent from the smaller comets, or it may develop as the comet approaches the sun. From the orbits of several hundred comets which have been defined, the majority are found to be parabolic, a large number elliptical, and a few hyperbolic; but as only a small portion of a comet's orbit—i.e. that which is in the vicinity of the earth and the sun—is observable, it becomes very difficult to distinguish between these curves. If some are hyperbolic, it appears certain that these comets leave the solar system never to return. The orbits of nearly a hundred comets are definitely known to be elliptical, so that their return to the sun may be predicted; these are called periodic comets.

Short-period Comets

Such comets are better known than the others, because in many cases the return of the same comet has been observed several times, as in the cases of Halley's comet and of Encke's comet, observed for 44 returns. It becomes possible to note the changes, both in the comet's period and in its structure, which have occurred in the intervals of their return.

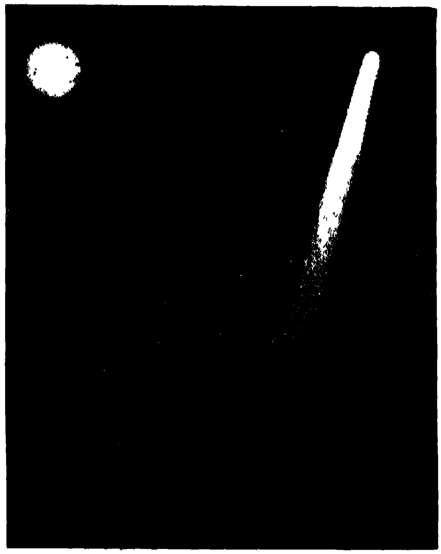
Generally the eccentricity of these cometary orbits is much greater than that of the planets and most planetoids. The comet approaches comparatively close to the sun at the perihelion end of its orbit, while the aphelion may be within the orbit of Jupiter or it may be far beyond that of Neptune; so the period of its return may be anything between 3½ years and 10,000 years. These comets are divided into two classes: (1) the short-period comets; (2) the long-period comets.

About 50 comets are known with short-period orbits, requiring between three and nine years for the comets to complete a revolution and return to perihelion. These comets are all faint objects, only a few being perceptible to the naked eye. They are usually known by the name of their discoverer; their full title states also the year of discovery and the order of discovery relative to others, thus: Geddes' comet 1932 *g*, and Faye's comet 1932 *h*, the letters in italics indicating that these comets were the seventh and eighth discovered in 1932.



ENCKE'S COMET. Discovered by J. L. Pons, of Marseilles, in 1818, this short-period comet is named after the German astronomer, J. F. Encke (1791-1865), who first determined its orbit and demonstrated that it had been previously observed in 1786, 1795, and 1805. The period of its recurrence or revolution about the sun is approximately 1,200 days.

There is another form of nomenclature used by astronomers, based upon the time the comet passes closest to the sun. This affords greater precision than the order of discovery, because a comet may overtake another which was found earlier and arrive at perihelion first. So in the case of comets discovered longer ago than a year or two, this form of nomenclature is usually adopted; it is expressed thus: Coggia's comet 1874 III, or Taylor's comet 1916 I. The Roman numerals replace the letters when the perihelion time is established.

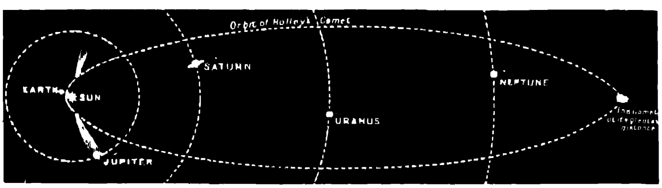


HALLEY'S COMET. This photograph shows the famous comet in relation to the planet Venus (left). A periodic comet, returning at intervals of 75 76 years, it has been observed for more than 2,000 years. The lower diagram shows its orbit.

Photo, Union Observatory, Johannesburg

Dominated by Jupiter

All these short-period comets have their aphelion point not far from the orbit of Jupiter—some within it to the extent of about 90,000,000 miles, as in the case of Encke's comet, which is the least of all. A few have it about 100,000,000 miles beyond Jupiter's orbit; on average, they are within 22,000,000 miles. A remarkable feature is that the inclination of their orbits to the ecliptic is within 30°, whereas, generally, comets' orbits are at all inclinations from 0° to 90°. Their motion is direct, that is, they travel round the sun in the same direction as Jupiter and the other planets. These are elements which indicate that these comets are an integral part of the solar system; also that they are a great family of comets dominated by Jupiter, which somehow has caused them to have these orbits; for this reason they are known as the Jovian family of comets. There are other very similar, though generally much larger, comets which have their aphelia comparatively near to the orbits of the outer planets: Saturn has thus a "family" of three comets, Uranus two, and Neptune eight, while Pluto also appears to possess some. There are also other groups whose aphelion points are several times the distance of Neptune or even Pluto; this seems to suggest the existence of other undiscovered worlds.



The best known of these families of comets is Halley's, so named because Halley computed its orbit for the first time and, having identified it with several which had previously appeared, predicted its return to perihelion in March 1759. He did not live to see this forecast verified, for he died before its return, but ever since it has been known as Halley's comet; it returned as predicted, on March 13, and with a tail 50 degrees long, that is, about 100 times the apparent width of the moon. The discovery of Halley's comet is lost in the mists of antiquity. The historical records of its return go back through the years 1682, 1607, 1531, 1456, 1301, 1145, to 1066, the year commemorated on the Bayeux Tapestry, which depicts Halley's comet. Thence it has been traced to 240 B.C.

From the evidence it is found that the comet returns at an average interval of 75 to 76 years, with a variation of about 18 months each way, due to planetary accelerations and retardations, its motion being retrograde. Following Halley's predicted return, it again appeared to time in 1835, but with a tail only 10 degrees in length, which occasioned some anxiety as to the possible condition of the comet at its next return in 1910. This was predicted with remarkable accuracy by the astronomers Cowell and Crommelin of Greenwich observatory.

Halley's Comet in 1910

The comet returned to perihelion on April 20 and proved the most sensational astronomical event for many years; it had regained all its old splendour and, through coming so close to the earth, surpassed itself as a celestial spectacle. The weather and conditions were not very favourable in Britain, but the comet was very well observed farther south and in America and the tropics.

It appeared at its best as an early morning object in the early part of May, when its nucleus rivalled the brightest stars and its tail attained a length of 60 degrees. Later, when at its nearest to the earth and only 14,300,000 miles

COMET'S STELLAR BACKGROUND. In this photograph of the comet Finsler, 1937, the slanting streaks represent the images of stars. This appearance is due to the movement of the comet relative to the stars during the long exposure that was necessary to take the comet's photograph – 5 hours 21 minutes.

Courtesy of the Royal Astronomical Society

away, the tail had broadened out to a band of luminosity resembling the Milky Way ; it was then about 120 degrees in length and stretched two-thirds across the sky, though the comet's head was not then visible. It is believed that the earth actually passed through the tail on May 21 of that year (1910). This comet may be regarded as typical of this class of periodic comets and a very good specimen, because it usually approaches close to our world.

Long-period Comets

The comets of long period, of which there are not many with *known* elliptical orbits, are best exemplified in a well-known group, two of the most famous being the comets of 1843 and 1882. These are so similar as to be almost identical. Both passed through the sun's corona at perihelion and less than 300,000 miles above the sun's surface, so from the earth they would have appeared less than half the sun's diameter away. In their close approach to the sun they resembled the long-period comets of 1668, 1880, and 1887. They had another common resemblance in approaching the sun from almost the same point in space the direction of the brilliant star Sirius —and in having almost identical elements of their orbits. It was as if they were various apparitions of the same object. The comets of 1843 and 1882 presented vastly different spectacles, owing to the different distances and perspective from which they were viewed by the various observers.

The comet 1843 I was calculated to have a period of between 400 and 800 years ; that of the comet 1882 III was computed to be between 600 and 900 years. It so happened that the 1882 comet, after passing very close to the sun, emerged as a " broken comet " and split into four divisions, which gradually parted company and travelled away into the depths of space as four comets along slightly different paths. The astronomer Kreutz calculated that they would return after a lapse of 664, 769, 875, and 959 years for each portion, when a great comet would be observed which would be only a fourth part of the original comet 1882 III.

Thus the singular grouping of the five great comets, those of 1668, 1843, 1880, 1882, and 1887, may be accounted for as being due to the division, long ago, of a still greater comet, following one of its close visits to the sun, like the comet of 1882.

Non-periodic Comets

The comets with parabolic orbits are the most numerous and, together with those having what appear to be hyperbolic orbits, the most mysterious. As these bodies usually become visible only somewhere within a limit of about 450 million miles, we may never even know the existence of all those with a perihelion distance beyond this. The greater proportion of these comets, about 63 per cent., come within the earth's orbit, and about another 30 per cent. between the orbits of the earth and Mars to perihelion.

About 300 new comets of this class (as distinct from the periodic comets previously considered) are discovered in a century, and the total must amount to several thousands. The question is whether they ever return. The relatively small portions of their orbits which are observable permit of the possibility that instead of parabolas they may be extremely elongated ellipses, in which their outward and return paths are almost parallel. This is *relative to the sun* ; but since the sun, together with the whole solar system, is travelling very rapidly in a certain direction in space, *relative to space* these comets' orbits would be far from parabolic. They might therefore be ellipses if they return, or hyperbolas if they do not.

There are about 20 comets whose orbits are apparently hyperbolic. When account is taken of the deviating attractions of the greater planets, particularly Jupiter and Saturn, it is found that the comet's paths, which may have originally been ellipses, have been distorted in passing these planets into hyperbolas, and so the comets will never return.

Thus the evidence inclines toward all comets being an integral part of the solar system, and the old belief that the parabolic and hyberbolic comets travel across space from star to star and visit our sun only once is improbable.

That comets are celestial bodies and not intangible phenomena is proved by their being governed by the force of gravitation. Therefore

they must have mass ; this is very small in proportion to their volume or bulk, and though it has not been found possible to measure a comet's mass definitely, it is certain that the largest comets do not contain more material in their composition than could be condensed into a sphere 10 miles in diameter. This small mass has been proved by the fact that comets exercise no perceptible perturbing or deflecting force on the planets, whereas planets produce great perturbations upon comets.

Composition of the Tail

Nearly all the body of a comet is contained within its nucleus, that is, the bright centre within its head or coma. Comets shine partly by reflected sunlight, but are to a certain extent self-luminous. While the coma and nucleus, if any, obey the laws of gravitation, the tail does not. This always curves and floats away into space in a direction opposite to the sun's attraction ; hence as a comet recedes from the sun after perihelion, its tail always precedes it. A comet may have more than one tail—perhaps three or four extending fan-shaped or as curved streamers, this effect being produced by the comet's motion.

The tail appears to be composed of exceedingly minute particles of matter generated by the comet in the form of highly rarefied gas. The particles are so small and light that the radiation pressure of the sun's light is greater than the sun's gravitational pull ; they are thus driven away into space, causing a continuous loss to the comet. In bright comets the particles composing the tail are seen being produced from the head as jets of light or as hollow luminous rings. The tail is frequently absent from smaller comets—as if all the finer particles which might enter into its composition had been lost. But a comet may develop a large tail and also a brilliant nucleus, originally absent, as it approaches the sun, the brightness of the comet continually increasing.

Dimensions of Comets

There is always a more or less globular head or coma, which, in a typical comet, contains a bright nucleus ; but in many instances, particularly in small comets, the nucleus may be absent and replaced by a more diffuse condensation. Occasionally the condensation is absent, particularly when the comet is at a great distance from the sun ; then the comet will frequently develop a nucleus as it approaches the sun, and will go through fluctuations of, brilliancy with successive outbursts of material which expand the tail. In a few exceptional instances the nucleus has been seen to become double (and even quadruple in the case of the comet 1882 III), but in these cases the phenomenon precedes division of the comet. The dimensions of comets impress by their vastness. The head of Halley's comet had at one time during its last visit a diameter of 550,000 miles, two-thirds that of the sun ; this had varied between 30,000 and 220,000 miles during most of its visibility while approaching and receding from the sun. The head of the comet 1811 I was over a million miles in diameter—much larger than the sun. On average, the heads of comets are between 10,000 and 150,000 miles in diameter.

The nucleus within the head or coma is much smaller, often not more than 100 miles in diameter. The nucleus of the comet 1811 I was only 428 miles at one time ; that of Halley's comet was only about 500 miles across. The nucleus of the comet 1882 III, before it divided, was 1,800 miles in diameter—one of the largest known. Donati's comet 1858 VI had a nucleus only about 630 miles across at a time when its tail was 45,000,000 miles in length. As with other parts of a comet, the nucleus varies considerably in size as it progresses in its path toward the sun. The nucleus of Donati's comet, for instance, varied between 5,000 miles and only 400 in width, shrinking as it neared the sun, but at the same time greatly increasing in brilliancy, while the tail expanded enormously. This comet had an elliptical orbit ; it is expected to return in about 2,000 years.

The comet 1811 I had a tail over 100,000,000 miles long, so it would have stretched farther than from the earth to the sun. The tails of the comet 1822 III were 60,000,000 miles long, with a diameter reaching to 15,000,000 miles. Their volume must have been colossal, yet stars will shine through all this cometary material with undiminished lustre. Schwarzschild calculated that there could not have been more material in 2,000 cubic miles of the tail of Halley's comet than there is in a cubic inch of ordinary air.

Composition of the Nucleus

The nucleus is much more substantial, spectroscopy revealing the presence of nitrogen, cyanogen, hydrocarbons, carbon monoxide, and radiations of sodium and iron when the comet is nearer the sun. These gases do not represent all the materials composing the nucleus, but only those which have radiations within the easily observable regions of the spectrum. The nucleus of comets is now regarded as composed of innumerable discrete particles ranging from the size of grains and pebbles to masses a hundred feet or more in diameter.

How close all these particles are together, or what is the nature and speed of their movements to produce the intense luminosity when near the sun, the emission of gases, and the material for their gigantic luminous tail, can at present only be inferred from the meteoric matter into which comets disintegrate.

BROOKS' COMET 1889 V. This comet passed so close to Jupiter that it became divided, the two parts being "captured" by the planet. The comet's previous 27-year orbit between Jupiter and the sun then became 7-year orbits for the two separated parts.

There is no doubt that comets gradually waste away ; they also part asunder and thus deteriorate ; this process was witnessed in the comet 1882 III, also in Taylor's comet 1916 I, a Jovian comet of short period, and in Brooks' comet 1889 V, which passed so close to Jupiter that it became divided, the two parts separating and following short 7-year orbits between Jupiter and the sun instead of the previous 27-year orbit. This was a clear case of "capture," as it is called, by Jupiter, which may account for all the Jovian "family" of comets. There are other instances where comets have divided and even vanished in consequence.

The most noteworthy is Biela's comet, which was seen to become double in 1846 ; it returned in two parts in 1852 and then vanished. Its period was about 6⅗ years. It should have appeared several times since but, instead, a brilliant meteoric display was witnessed when the earth crossed its path. Remnants of this comet occur as meteors, destroyed in the earth's atmosphere each November.

Theories of Origin

The origin of comets is still a problem. One theory is that the material of comets originated in a meteoric or cosmic dust cloud a million or so years ago, and that the solar system in its journey through space passed through such a cloud. A more probable theory is that comets represent material ejected from the sun and planets millions of years ago, when their eruptive activity was far more violent than now. Another suggested solution is that comets originate in a vast quantity of exceedingly rarefied material encircling the outer periphery of the solar system, many times beyond the orbit of Neptune, to include the orbits of comets with periods approaching 10,000 years.

At such distances the speed of a comet would amount to only a few yards a second ; this would slowly increase until a speed approaching 30 miles a second would be attained as it passed the earth's orbit. On nearing the sun this would rapidly increase in proportion to the nearness of the comet's perihelion to the sun's surface. Comet 1882 III sped round the sun with a velocity of 300 miles a second.

The possibility that a comet's nucleus can strike the earth must be admitted, but from elaborate calculations the chances would appear to be one in many millions of years. Such collision would amount to no more than a local and dense fall of meteorites There are evidences that such falls have occurred, and these are discussed in the next Lesson.

LESSON 20

Meteors and Meteorites

METEORS produce the streaks of light occasionally to be observed shooting across the night sky, and are therefore commonly called "shooting stars." They are not stars, and they do not shoot but fall. Sometimes one or more of these bodies will reach the earth's surface before being completely destroyed, and these are called meteorites or aerolites. It is possible to see an occasional meteor on any dark, starlit night when the moon or artificial lights are absent. On rare occasions a meteor will appear as bright as Venus or Jupiter and last for two or three seconds, leaving a luminous train, which will remain sometimes for a minute or two. Still more rare are the splendid meteors which light up the landscape, and have even been seen in daylight ; these are commonly called fireballs (a term which must not be confused with the electric phenomena associated with thunderstorms).

These different types of meteor have not the same origin, though they are all individual bodies travelling freely through space and from distances amounting to hundreds of millions of miles—in some instances, thousands of millions—far beyond the orbit of Neptune.

While speeding through interplanetary space, meteors are invisible on account of their small size; they appear only after penetrating the earth's atmosphere, and when they are at a height of between 80 and 100 miles above the earth's surface. Then they become visible through ignition, in consequence of the heat generated by friction against the air, which is intense at the speed at which they are travelling—and, as a rule, the meteor is consumed.

Speed of Meteors

The average speed at which meteors travel when near the earth is about 26 miles a second, but if our world and the meteors are approaching head on, as it were, the observed speed may amount to over 40 miles a second. The speed of meteors approaching the earth obliquely, or from the rear, will seem relatively much slower, their apparent velocity being only a few miles a second. Such meteors are more likely to reach the earth's surface, since their combustion is slower, they usually appear reddish and less bright. The meteors which do not reach the ground may disappear at any height; because most of them are very small, they vanish when between 50 and 30 miles above the surface.

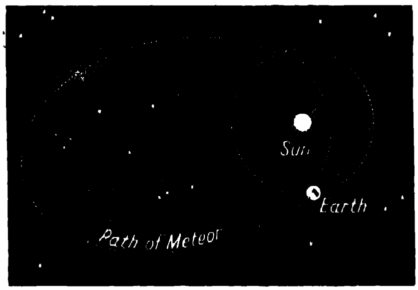
While the number of meteors counted by a single observer on a fine dark night may amount to between six and eight an hour, on some nights this may be increased, until at certain times it can exceed 60 meteors an hour. Though the arrival of large individual meteors cannot be predicted, there are meteor swarms or showers which appear with a periodicity that can be foretold to within a day or two.

Meteor Radiants

The meteor swarm of a particular period will be seen to come from a certain spot in the sky if the meteors are traced back to their intersection. This point is called the radiant; it is the same for all observers, and represents the direction from which the meteors approach the earth before they enter its atmosphere. Each swarm of meteors has its own particular radiant, the meteors from which are named after the constellation in which the radiant is situated—as, for instance, the Leonids, from Leo. Sometimes, when more than one radiant is known to be in a constellation, it is named after a particular star which appears near by, such as the Alpha Leonids, which are distinct from the foregoing. The stars have no connexion whatever with the meteors, serving merely to indicate the direction from which they arrive.

The meteor radiant is defined according to degrees in right ascension and declination on the celestial sphere. These are the imaginary lines which correspond to those of longitude and latitude on the terrestrial sphere. The whole of the meteors from a particular radiant are called a meteor swarm, and each swarm has its peculiarities in addition to the date of appearance; some swarms are swift meteors, those from other radiants slow, some swarms are reddish, and others are bluish.

If any one swarm or shower (as it is called when the display takes place) is watched throughout the night, the number of meteors seen usually increases towards the morning hours; the observer is at that time nearer the apex or direction of the earth's motion in her orbit. He is, as it were, then at the front of the earth, whereas in the evening he is at the rear, and the effect is comparable to the greater number of raindrops caught in front by a person advancing against a downpour.



ORBIT OF A SWARM OF METEORS. Swarms of meteors travel in orbits around the sun, becoming incandescent when they encounter the earth's atmosphere. A swarm may be a few hundred miles thick, and its length hundreds of millions of miles.

Remarkable Swarms

Quite the most remarkable among the meteor swarms are the Perseids, Leonids, Andromedids, Lyrids, γ Aquarids, η Draconids, and α Capricornids. These have on many occasions provided superb displays. The Perseids, once known as the Tears of St. Lawrence, are to be seen from midnight, when their radiant is low in the north-east, throughout the night until between 3 and 4 a.m., when the radiant is almost overhead and the meteors appear to fall from the zenith. They are very swift, usually small, and their paths short, an average of 60 an hour being often counted at their annual display, and at times this will be doubled. Although the maximum occurs at some time between August 10 and 12, some of these meteors are to be seen 3 or 4 weeks beforehand.

The Leonids have provided the most famous meteor showers. The first record of their having been observed is in A.D. 902, and subsequent records show that the shower comes in greater brilliancy and profusion thrice a century.

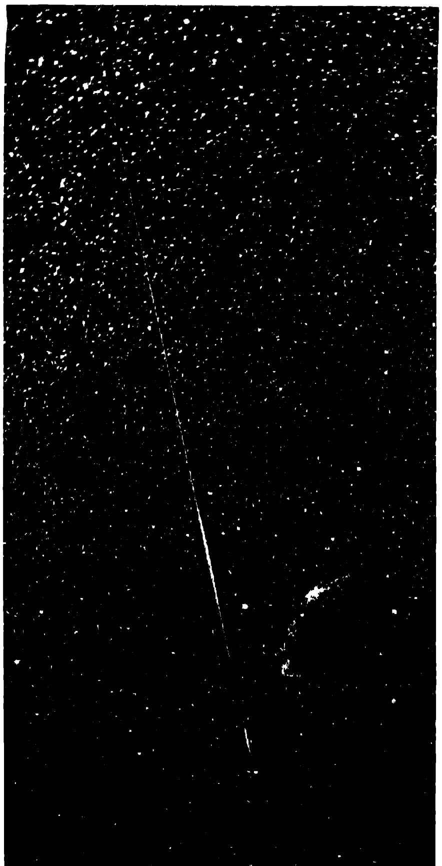
Every year a few of the swarms are to be seen ; they are low in the east about midnight, their numbers considerably increasing afterwards until they attain their maxima about 5 a.m. Then they appear high up in the south. These meteors have not been very numerous in recent years, but on occasions the display has been superb. In 1799 they resembled fireworks from a celestial fountain, pouring from the radiant and spreading out over the sky. This appearance is the effect of perspective, for actually the meteors travel in parallel paths. In 1833 this grand shower was repeated, 200,000 an hour being the estimate of some observers. The display lasted about six hours.

An investigator, H. A. Newton, predicted in 1864, from a study of past records, a return of this Leonid swarm to take place on November 13 or 14, 1866. It came true to time, and was in a lesser degree repeated in the following year. Then J. C. Adams, of Neptune fame, computed the orbit of this meteor swarm, and found that the meteors travelled in a long stream over a very elliptical orbit, a more concentrated mass of the meteors constituting the grand swarm. These cross the earth's path every 33 to 34 years, when our world is in their vicinity, the meteor shower being the effect of numbers of them colliding with the earth's atmosphere.

It was expected that the shower would be repeated in 1899 or 1900, but the results were disappointing, except that early on the morning of November 15, 1901, many thousands of the meteors were observed in western North America. It is thought that the main swarm has been deflected by Jupiter and other planets. More recently, 50 Leonides an hour have been counted, the normal annual display.

Methods of detecting distant aircraft by reflection of short radio waves developed during the Second World War were applied, after it ended, to the study of meteor trails, regions of the upper atmosphere consisting of intensely hot (and therefore electrically conducting) gas caused by the passage, seconds before, of a meteor through the air. Radar reflections from these trails, picked up by suitably placed detectors, can be made to yield information about heights, speeds, and orbits of the meteors that is unobtainable by visual or photographic means. Also, observations are possible in daylight, moonlight, and through cloud.

Moreover, radar can give the speed of a meteor simply and far more accurately than visual estimates, which are little more than guesses. By these means it has been established in the last few years that there is greater meteor activity in the daytime than at night, especially in the summer months. It is now also known that no meteors enter the atmosphere at hyperbolic velocities, i.e. all meteors are members of the solar system.



METEOR'S JOURNEY through the earth's atmosphere. In this telescopic photograph the white line reveals the second-long passage of a meteor, rendered incandescent by friction with the air. The white body to the right is a nebula.

Meteorites or, as the larger specimens are often called, aerolites are those fragments of meteoric material which survive entire combustion and reach the earth's surface more or less intact ; in many instances they are subsequently found deeply embedded in the ground. Large luminous bodies of this class, while travelling through the sky, are sometimes called bolides and fireballs. The meteorites are always the remains of these large bodies ; a considerable portion of their material has become vaporised and entered the atmosphere as gases and dust during their swift incandescent passage to the ground. If their velocity is greater than about six miles a second, the frictional resistance of the air will generate this incandescence, and because the speed at which they enter the atmosphere usually far exceeds this—amounting sometimes to 40 miles a second—the heat generated and the loss of material are considerable; only a residue of the less combustible elements is left, which explains why meteorites are such heavy bodies. Much of the vaporised material enters into the

METEORIC SCARS. In South Carolina, U.S.A., there is an area of more than ten thousand square miles containing a large number of scars or " bays " elliptical depressions in the earth with features which suggest that they were caused by a vast shower of meteorites a million or so years ago.

composition of the earth's atmosphere as gas, while a proportion subsequently falls as meteoric dust. In Arctic regions this dust is perceptible, and may be collected from the snow ; traces have also been found in samples of the sea-bed. Thus it will be seen that there is a constant accretion by the earth of meteoric matter, but this can scarcely exceed a few score tons a day.

Meteoric Fireballs

In the case of the large spectacular meteorites commonly called fireballs, the period of incandescence is too short to consume more than an outer layer, the interior being unaffected if the fireball remains intact. Fireballs have been found quite cold soon after reaching the ground. The length of time occupied by these solitary fireballs in their flight will often amount to several seconds, their paths frequently reaching to between 100 and 2,000 miles in length. Their progress is often irregular, becoming perceptibly slower owing to air resistance ; ultimately it may be reduced to less than 10 miles a second.

The spectacle is occasionally very fine, as the meteoric fireball strews its path with sparks of varied colours and lights up the landscape as brightly as the full moon ; sometimes fireballs rival the moon in apparent size. A roar or thunderous sound frequently follows their appearance, and, because some of them explode, they are known as detonating and bursting meteors. They usually leave a trail behind, produced by the hot luminous vapours given off in their flight ; this may last for several minutes, or longer in exceptional cases. Their paths can be measured with exactitude, and their height, vanishing point, and size calculated from observations at different points by two or more observers of the same object.

Between four and five are to be seen annually in one locality ; from this it is to be inferred that the actual number of large meteoric fireballs, which annually become part of the earth, must amount to thousands. The great majority will fall in the sea, as its area is so much larger than the land. Many thousands have been collected, and are in various museums and private collections of the world. These are chiefly the heavy metallic meteorites, sometimes called siderites. Because of their weight and crystalline exterior, they are easily recognized. The stony meteorites, which constitute the great majority of the recovered particles of the meteorites seen to fall, are often overlooked on the ground because their appearance is that of common stones.

An exceptionally fine meteorite was observed early in the morning of March 24, 1933, in Mexico, Texas, Kansas, Arizona, and Colorado. It first appeared at a height of about 65 miles above Oklahoma state, and disappeared at a height of between 6 and 8 miles over a point in the state of New Mexico. Its detonations were heard in five states ; they were accompanied by a roar likened to artillery, rattling of windows, and vibrations of the ground.

On October 9, 1933, a fine display of meteors followed the return of Giacobini's comet of 1900, which seems to indicate that meteor swarms accompany disrupted comets. On January 3, 1935, a brilliant fireball was seen at a height of 55 miles over the English Channel, 23 miles south of Christchurch, passing 20 miles above Wotton-under-Edge, Glos. It was described as being brighter and larger than the full moon and producing a chain of sparks visible for nearly three seconds. As during this time it travelled only 92 miles, it was a slow fireball ; it changed colour and finally broke into two pieces. A detonation heard at Bradford-on-Avon was due to the meteor's rush giving rise to shock waves sounding like thunder. A shower of brilliant meteorites was seen in southern Sweden during the evening of May 27, 1938, together with two extraordinarily bright fireballs. On October 2, 1938, a fireball was seen for 30 seconds from Brittany, about the size of the full moon and with a red trail. Rarely, if ever, can any connexion be traced between these isolated bright fireballs and the known annual showers.

Metallic and Stony Meteorites

Meteorites or aerolites, after cooling, often have a crystalline exterior, and are covered with what appears to be a black carbonised glaze. This is the result of surface fusion and subsequent

rapid cooling. There are two characteristic varieties, the metallic or "iron" meteorite, and the uranolith or "stony" meteorite. The metallic examples are usually composed of masses of iron, together with nickel, cobalt, magnesium, and other elements. The stony examples are masses of crystalline rock, and these masses often have peculiar crystals of familiar elements, such as limestone, magnesian, and siliceous stone; faulting, veins, fragmentation, and re-cementation, which are frequently perceptible, are indications that the meteorites were composed of old rocks and material blown out of volcanoes, or were the particles of a disrupted world. Numerous elements found in meteorites include iron, nickel, oxygen, silicon, magnesium, sulphur, calcium, cobalt, aluminium, sodium, argon, and helium; hydrogen, nitrogen, carbon monoxide, hydrocarbons, and phosphide of iron are present in different chemical combinations.

Gigantic Specimens

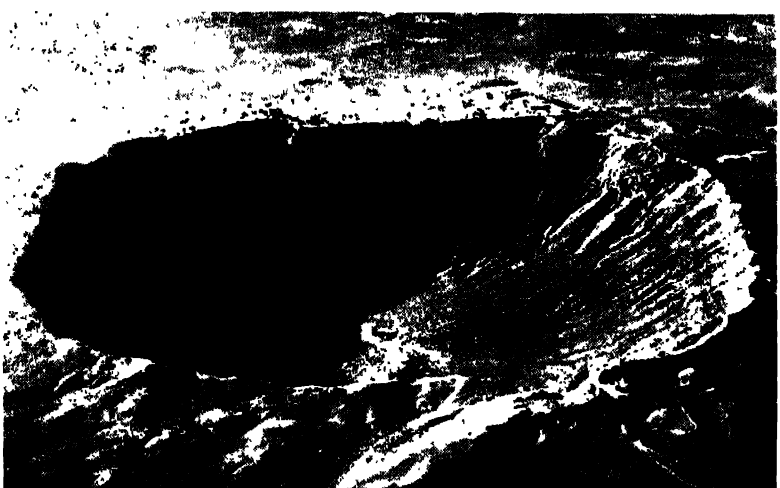
Notable meteoric masses are to be seen in museums. The Natural History Museum, South Kensington, London, has a fine collection; one specimen weighing about 3½ tons was found at Cranbourne near Melbourne Australia, in 1854. One of the oldest meteorites of the fall of which there is an authentic record is suspended by a chain in the parish church of Ensisheim, in Alsace; the record states that on November 16, 1492, a crash of thunder and prolonged noise were heard, and a stone weighing 260 lb. was seen by a child to fall in a field, making a hole more than five feet deep.

The black stone of Mecca, in the sacred Ka'aba, is an ancient meteorite. The primitive "image" of Diana at Ephesus, which was regarded as having fallen from the god Jupiter, was doubtless a meteorite. A Chinese record of 616 B.C. refers to a meteorite which killed 10 persons. Livy mentions a fall of meteorites occurring about 650 B.C. The astronomer Gassendi saw one which weighed 59 lb. fall in Provence in 1627. A very large single mass was found in Greenland and brought thence to the Museum of Natural History in New York; it weighs 37½ tons. Another specimen was found in Brazil, weighing 6 tons. One still remaining in the ground in Mexico weighs about 60 tons.

Multiple Fireballs

These bodies do not always travel singly. A fireball may consist of large numbers of smaller bodies, all massed together. Such a fall occurred at Pultusk, in Poland, on January 30, 1868, when over 100,000 were estimated to have fallen. In 1510 a large number fell near Padua, some weighing up to 100 lb. Between 2,000 and 3,000 aerolites fell at L'Aigle, in France, on April 26, 1803. At Mocs, in Hungary, on February 3, 1882, over 100,000 were estimated to have fallen. About 14,000 fell in Arizona on July 19, 1912.

Most mysterious and devastating was the fall which apparently occurred on June 30, 1908; though the fall was not actually observed, a very brilliant light was seen in the sky from the east of Scotland and elsewhere in northern Europe. Even at Greenwich a strange glare was noted, resembling the dawn, and many places reported the period before midnight becoming as light as day. Subsequently it was found that peasants in Siberia reported a great explosion, earthshock, and earthquake vibrations north of Irkutsk, where there was much destruction. The area was explored in 1927, and a group of meteor craters were found containing at least 130 tons of meteoric stones. The forests for 40 miles from the scene were



A METEOR CRATER IN ARIZONA. Ages ago a celestial projectile of vast dimensions fell in the desert of north-west Arizona, and Meteor Crater, near Winslow, is the abiding memorial of the terrific collision. The cavity measures 1,500 yards in diameter, is 600 feet deep, and is surrounded by a ridge, 150 to 200 feet high, of matter thrown up by the impact. Scattered about the slopes and adjacent plain are fragments of meteoric iron, rocks, and boulders.

Photo, H. J. Shepstone

destroyed, the trees being laid flat. In 1945 a similar but less disastrous fall, resulting in the creation of dozens of deep craters each several yards in diameter, occurred on the Pacific coast of the U.S.S.R.

Most famous of all evidences of past meteoric falls is the great meteor crater in Arizona, situated near Winslow and the Cañon Diablo, far from all volcanic activity. It presents a depression 600 feet deep and about 4,500 feet in diameter ; thousands of iron meteorites have been found there, and doubtless large numbers remain buried beneath the crushed masses of rock. Another crater is known in Texas, 530 feet in diameter. A group at Henbury, in Australia, has one crater about 600 feet in diameter. In South Carolina an area of 10,000 square miles is pitted with meteoric scars.

LESSON 21

Some Unsolved Problems of the Solar System

IN the preceding survey of the various bodies that constitute the solar system, we have considered those which are individually visible and may be studied as separate units of the whole. There remain certain fascinating phenomena which cannot be so studied. The most notable of these are the zodiacal light and the Gegenschein.

The zodiacal light can be observed in the west soon after twilight has vanished, and also in the east just before dawn. It produces a faint cone of light, appearing in British latitudes as slightly tilted. This cone of light is best seen in the evenings in spring, when it slopes upwards towards the left from where the sun has set. In the mornings it is best seen in the early autumn, when it will slope towards the right from about where the sun will rise later.

A clear and rather dark moonless sky is necessary to reveal the cone of pearly zodiacal light. It is brightest near the horizon, and extends to about 45 degrees from the sun —which has to be some distance below the horizon before the light becomes perceptible. Much depends upon the clearness of the atmosphere and the angle which the cone subtends to the horizon ; hence spring and autumn are best for observation, for then the cone of light is nearer to perpendicular than in summer or winter, because it follows the angle of the ecliptic, or zodiac.

Origin of Zodiacal Light

This singular light has been found, spectroscopically, to be the same as sunlight reflected from the moon and, like it, it is partially polarised. Thus it is evident that the zodiacal light is reflected from solid particles too small to be perceptible, even through most telescopes. Close observation in tropical lands has shown that the light in a very faint degree extends across the sky to a small intensification of the zodiacal light called the Gegenschein, which appears in the opposite side of the sky and covers an area about 10 degrees in diameter. The centre of this Gegenschein, or "counter-glow," is directly opposite the sun.

There exists a large lenticular-shaped belt of small bodies or particles encircling the sun and extending to beyond the earth's orbit ; the zodiacal light is that which is reflected from the particles within the circumference of the orbit, while the light of the Gegenschein comes from particles outside its circumference. They must be small, approximating to meteors in size, and several miles apart - otherwise the combined mass would sensibly affect the motions of the earth, Venus, and Mercury in their orbits.

ZODIACAL LIGHT. Drawing showing the luminosity that appears in the west sky after twilight or in the east before dawn. Though best seen in the clear skies of the East, it can be observed from London and other places. The light may be caused by the reflection of sunlight from meteoric masses still in the original plane of the solar system.

When one considers the myriads of these particles, together with the innumerable meteors which are speeding in some thousands of streams along their elliptical orbits to and from the sun, one realizes that interplanetary space is far from being empty, although visually it appears so. It has been calculated that 20,000,000 meteors large enough to be visible to the naked eye enter the earth's atmosphere every day, and thus become part of our world. Hence there is a constant accretion of material, which must result in the gradual growth of this and other planets.

This material has been calculated to amount to about 36,500 tons per annum on average that is, assuming that something like 100 tons fall to the earth every day from the 20,000,000 meteors. These estimates, though necessarily vague, are based upon observed facts.

The deposition of this amount of material would require about 1,000,000,000 years to accumulate a layer one inch thick over the earth's surface. Planetary growth by this means is therefore exceedingly slow, but it may not have been so in the distant past, when quite possibly meteoric matter was far more prolific than it is at present.

Origin of Meteors

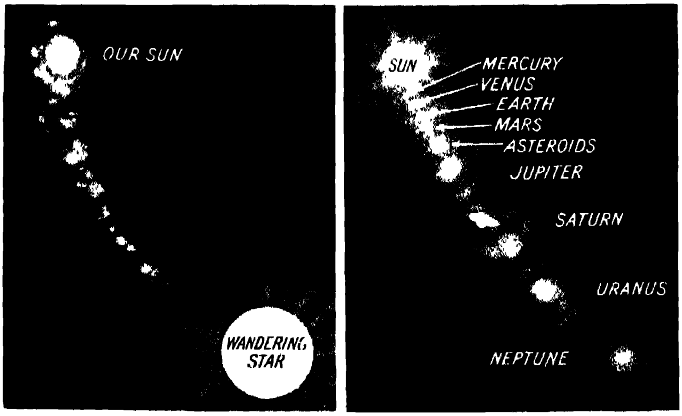
Have the planets grown by the accretion of meteoric matter through the long aeons of time ? If they have, whence have come the meteors ? Some meteor swarms represent disintegrated comets, others the residue of known comets. For example, the residue of Tuttle's comet of 1862 produces the Perseid meteors of August 10–12 ; the Leonids of November 15–16 are the residue of Tempel's comet of 1866 ; the Andromedid meteors of November 17–23 are the disintegrated Biela's comet, which was seen to part asunder and has since vanished. The Aquarids of May 2–6 are the residue of Halley's comet. The Pons-Winnecke comet appears to be responsible for the Draconids of June 27–30, and the Comet 1881 V for the Capricornids of July 24–26. It seems that the nucleus in the head of a comet is a great concentration of meteoric bodies or particles all pursuing independent but nearly identical paths, their collisions increasing as the comet approaches the sun.

It may therefore be inferred that all meteor streams are the product of cometary disintegration. If it could be proved that all comets originally entered the solar system along hyperbolic paths from outer space, paths which were subsequently transformed in many cases into elliptical paths, we should have a possible source of the meteoric material from which in the course of ages the planets have grown. This, in brief, is the meteoric theory of the growth of worlds and systems.

There are other theories which approach this problem from different standpoints of ascertained facts, and even to the extent of accounting for the origin of the planets and their remarkable series of similarities—such as their common direction of orbital motion, rotation, the closeness of the planes of their orbits, the singular sequence of their proportionate distances from the sun as represented by Bode's law, together with the way in which the sun's equator and its rotation conform to the equator and rotation of the revolving planets.

Laplace's Nebula Hypothesis

The nebular hypothesis of Pierre S. Laplace (1749–1827) is the oldest and best known of these theories, and may be stated as follows. Suppose we have a nebula or cloud of primordial luminous mist—say, some 6,000,000,000 miles in diameter. This nebula must be subjected to two distinct causes of change. First, all its material particles must attract one another by the law of gravitation, so that the nebula tends to condense towards the centre ; simultaneously, the luminous or incandescent particles composing the nebula would be constantly radiating heat out into space. Such a nebula could not for a moment remain at rest, even if it was originally in such a condition—which is virtually impossible. For as it gradually radiated its heat, it would contract, and however slow its initial rotation about an axis, this would gradually become more rapid, to preserve its angular momentum.



TIDAL THEORY OF THE SOLAR SYSTEM'S ORIGIN. One theory concerning the origin of the solar system of sun and circling planets is that at some remote date a " wandering star " came so near to the as yet planetless sun as to cause tremendous waves on its surface and ultimately the drawing away into space of vast blobs of matter which settled down to become planets

The speed near the edge of the rotating mass would overcome the pull of gravity sufficiently for this to resist further shrinkage, and eventually a separate ring of matter would become detached and continue rotating under its own centrifugal force.

Subsequently other rings would form in the same way at regular intervals The material of the rings would, under various gravitational perturbations, tend to coalesce in masses, eventually forming spherical bodies or planets, which would continue to revolve round the central nucleus that in time condensed into the sun. Each of the revolving masses, while hot enough to preserve its nebulous condition, and having acquired a rotation from tidal attraction of the central mass, would, when rapid enough, also shed minor rings, which in time would form spheres or satellites (except in the case of part of Saturn which preserved the rings). The asteroids or planetoids might also be regarded as an instance in which the nebulous ring failed to coalesce into a planet. But there are various difficulties in the way of accepting this theory

Tidal Theory of the Solar System

The tidal theory or, as it is technically called, the Hypothesis of Dynamic Encounter, is a more recent suggestion, which avoids some of the difficulties of the nebular hypothesis. It assumes that the sun was at one time without planets ; then another sun, or "wandering star," approached sufficiently near to raise enormous tides on our sun. These tides, reaching thousands of miles in height, caused the material to be drawn away from the sun into space.

The illustration in page 1730 gives a good idea of the suggested process and the ultimate evolving of the planets as a consequence. The "wandering star's" attraction would tend to impart a motion to the original mass in a direction similar to that in which the star was travelling, and thus the "embryo" planets would begin travelling in what were later to become their orbits. This ingenious hypothesis thus explains the angular momentum or speed possessed by the planets in their orbits, and also it accounts for the sun's rotation in harmony therewith.

Other Solar Systems

But an assumed "wandering star" fails to account for the many satellite systems such as those presented by Jupiter and Saturn, which, on this "wandering star" hypothesis, would need other "wandering stars" for their production ; all in a similar plane as well, which is most improbable. Recent discoveries among stellar "solar systems" have tended to show that the disturbing pull of a "wandering star" is unnecessary. Modifications of this tidal theory, such as the one which identifies ten planets with remnants of a stellar explosion, avoid some of the difficulties but raise fresh ones. No explanation of the origin of the planets yet commands general assent.

LESSON 22

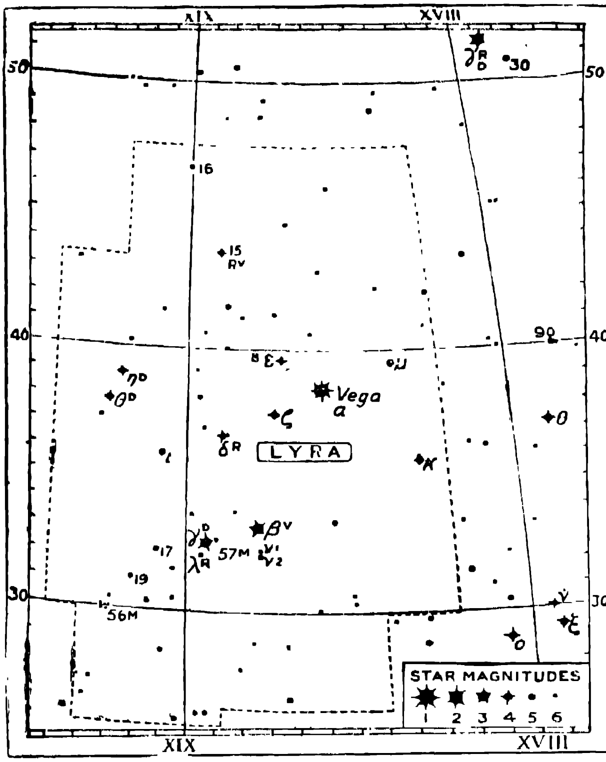
Ancient and Modern Star Groupings

In their nature and constitution, the stars are more or less similar to our sun. But the sun is a star far advanced in stellar evolution, and therefore much smaller than most other stars. About 2,000 stars can be seen at one time over the half of the heavens visible on a very clear and dark night, but haze and artificial lights normally reduce this number to less than half. Field-glasses will increase the number to 20,000 or 30,000 ; to these must be added about half as many again which are below the horizon and will come into view in due course. There are also about 25 per cent. more which are for ever out of sight in Britain, but can be observed from southern latitudes.

Grouped in Constellations

The telescope greatly increases the number visible with each increase of power, until about a thousand million are revealed by the most powerful instruments, and many more are known to exist in masses in which the individual stars are indistinguishable. The total number has been variously estimated at fifty to a hundred thousand millions.

The stars are grouped by astronomers in certain constellations, of which there are 89 now in general use (*see* p. 1733) ; 48 have continued from the time of Ptolemy, including the zodiac and the larger constellations containing bright stars visible from the northern hemisphere. Most of these date from early Chaldean times and were "placed" in the sky by the astronomer-priests of the Euphrates valley ; it appears evident that they were not Egyptian, Hindu, or Chinese in their origin, because there are neither elephant, crocodile, tiger, hippopotamus, nor cat among the numerous animals represented —some of which creatures would have doubtless been introduced had the constellations originated in any of those countries. There were Egyptian, Greek, and Roman changes at a later date. Deities famous in Greek



TYPICAL STAR MAP. The vertical lines are those of right ascension, divided into hours. The horizontal lines are those of declination, divided into degrees. The dotted lines indicate the constellation of Lyra (English name Lyre). It contains the brilliant Vega.

and Egyptian mythology were introduced, and names have in many instances been latinised : for instance, Hercules, Leo, Virgo.

Boundaries of Constellations

The Chaldean constellations originally typified the annual succession of ordinary events in the lives of those ancient peoples—events which were believed to be presided over by their sun-god and moon-god, whose position relative to the various groups of stars signified seedtime, harvesting, hunting period, rainy season, midwinter, midsummer, and so on. The story of the Flood has been traced in the arrangement of some of the constellations, and the Argonautic expedition of the ancient Greeks was undoubtedly thus symbolised. In addition to these ancient groups there are about 40 constellations, invented since 1600, chiefly by Johannes Hevelius (1611–87) and Johann Bayer (1572–1625), to fill in gaps between the older constellations and also to include the stars surrounding the south celestial pole. Most of these added constellations are insignificant, and some have been discarded.

The boundaries of the constellations originally followed irregular curves, sometimes vaguely suggesting the object represented. In 1930 the International Astronomical Union adopted a plan in which the boundaries follow the lines of right ascension and declination corresponding to terrestrial longitude and latitude; the resulting angular arrangement suggests the boundaries of many American states.

Nomenclature and Magnitudes

The student should study the four star maps reproduced in pages 1735 and 1736, and should acquire a star atlas in order to become acquainted with the position of the thousands of objects visible in the celestial dome. The stars are presented according to magnitudes with either their proper names, Greek alphabetical designation, that of Roman numerals, or some catalogue nomenclature, together with other abbreviated information, such as V for variable star, R for red. Novae or new stars, star clusters, and nebulae also are indicated.

The name of the constellation follows the Greek letter or the numeral, e.g. β Lyrae, ζ Virginis, 81 Ursae Majoris or 26 Geminorum. The genitive case is always used. The list in page 1733 gives (1) the English name of the constellation; (2) its Latin equivalent; (3) the genitive case in which each is expressed; (4) the abbreviated form in which each constellation is now usually written.

About 140 of the brighter stars have names; these are of great antiquity, usually Greek, Latin, or Arabic. Only about 60 are in general use, the technical nomenclature according to the letters of the Greek alphabet being preferred, particularly since they give some impression of the relative brightness of the brighter stars in a constellation, α usually being brighter than β, and so on until ω is reached, when the Roman numerals are resorted to. The stars are then much fainter and approaching the limit of naked-eye visibility.

The brighter stars will thus have two titles: for example Sirius, which is also α Canis Majoris or, as it would be written, α CMa. Castor is also α Geminorum, Pollux is also β Geminorum, otherwise α Gem. and β Gem. But in this particular instance β is brighter than α, possibly owing to a change of relative brilliance in the course of centuries since Johann Bayer, in 1603, instituted this special method of designating noteworthy stars.

CONSTELLATIONS AS DEFINED BY THE INTERNATIONAL ASTRONOMICAL UNION IN 1930

(List arranged in alphabetical order of Latin names)

English Name	*Latin Name*	*Genitive Form*	*Abbreviation*	*English Name*	*Latin Name*	*Genitive Form*	*Abbreviation*
Chained Lady	Andromeda	Andromedae	And.	**Lizard***	Lacerta	Lacertae	Lac.
Air Pump*	Antlia	Antliae	Ant.	**Lion**	Leo	Leonis	Leo.
Bird of Paradise*	Apus	Apodis	Aps.	**Lesser Lion***	Leo Minor	Leonis Minoris	LMi
Water Bearer	Aquarius	Aquarii	Aqr.	**Hare**	Lepus	Leporis	Lep.
Eagle	Aquila	Aquilae	Aql.	**Balance**	Libra	Librae	Lib.
Altar	Ara	Arae	Ara	**Wolf**	Lupus	Lupi	Lup.
Ship Argo	Argo	Argus	Arg.	**Lynx***	Lynx	Lyncis	Lyn
Ram	Aries	Arietis	Ari	**Lyre**	Lyra	Lyrae	Lyr
Waggoner	Auriga	Aurigae	Aur	**Mast* (of Argo)**	Malus or Pyxis	Mali	Pyx.
Herdsman	Bootes	Bootis	Boo.	**Table Mountain***	Mensa	Mensae	Men.
Sculptor's Tool*	Caelum	Caeli	Cae	**Microscope***	Microscopium	Microscopii	Mic.
Giraffe*	Camelopardus	Camelopardi	Cam	**Unicorn***	Monoceros	Monocerotis	Mon
Crab	Cancer	Cancri	Cnc	**Bee***	Musca (Apis)	Muscae	Mus.
Hunting Dogs*	Canes Venatici	Canum Venaticorum	CVn	**Rule***	Norma	Normae	Nor.
Dog	Canis Major	Canis Majoris	CMa.	**Octant***	Octans	Octantis	Oct
Lesser Dog	Canis Minor	Canis Minoris	CMi.	**Serpent Bearer**	Ophiuchus	Ophiuchi	Oph
Sea Goat	Capricornus	Capricorni	Cap	**Giant-Hunter**	Orion	Orionis	Ori
Lady in the Chair	Cassiopeia	Cassiopeiae	Cas	**Peacock***	Pavo	Pavonis	Pav.
Keel* (of Argo)	Carina	Carinae	Car	**Winged Horse**	Pegasus	Pegasi	Peg.
Centaur	Centaurus	Centauri	Cen	**Rescuer**	Perseus	Persei	Per.
Monarch	Cepheus	Cephei	Cep	**Phoenix***	Phoenix	Phoenicis	Phe
Sea Monster	Cetus	Ceti	Cet	**Painter's Easel***	Pictor	Pictoris	Pic.
Chameleon	Chamaeleon	Chamaeleontis	Cha	**Fishes**	Pisces	Piscium	Psc.
Compasses*	Circinus	Circini	Cir	**Southern Fish**	Piscis Australis	Piscis Australis	PsA
Dove*	Columba	Columbae	Col.	**Poop* (of Argo)**	Puppis	Puppis	Pup.
Berenice's Hair*	Coma Berenices	Comae Berenices	Com.	**Net***	Reticulum	Reticuli	Ret
Southern Crown	Corona Australis	Coronae Australis	CrA	**Arrow**	Sagitta	Sagittae	Sge.
Northern Crown	Corona Borealis	Coronae Borealis	CrB	**Archer**	Sagittarius	Sagittarii	Sgr.
Crow	Corvus	Corvi	Crv.	**Scorpion**	Scorpius	Scorpii	Sco.
Cup	Crater	Crateris	Crt	**Sculptor's Workshop**	Sculptor	Sculptoris	Scl.
Cross (Southern)*	Crux	Crucis	Cru	**Serpent**	Serpens	Serpentis	Ser.
Swan	Cygnus	Cygni	Cyg	**Sextant***	Sextans	Sextantis	Sex.
Dolphin	Delphinus	Delphini	Del.	**Bull**	Taurus	Tauri	Tau.
Swordfish*	Dorado	Doradus	Dor.	**Telescope***	Telescopium	Telescopii	Tel.
Dragon	Draco	Draconis	Dra	**Toucan***	Tucana	Tucanae	Tuc.
Little Horse	Equuleus	Equulei	Equ	**Triangle**	Triangulum	Trianguli	Tri.
River Eridanus	Eridanus	Eridani	Eri.	**Triangle (South)**	Triangulum Aust.	Trianguli Aust.	TrA.
Furnace*	Fornax	Fornacis	For	**Bear**	Ursa Major	Ursae Majoris	UMa.
Twins	Gemini	Geminorum	Gem.	**Lesser Bear**	Ursa Minor	Ursae Minoris	UMi.
Crane*	Grus	Gruis	Gru	**Sails* (of Argo)**	Vela	Velorum	Vel.
Hercules	Hercules	Herculis	Her.	**Virgin**	Virgo	Virginis	Vir.
Clock*	Horologium	Horologii	Hor.	**Flying Fish***	Volans	Volantis	Vol
Sea Serpent	Hydra	Hydrae	Hya.	**Fox***	Vulpecula	Vulpeculae	Vul.
Water Snake*	Hydrus	Hydri	Hyi.	**Sobieski's Shield***	Scutum Sobieski	Scuti	Sct.
Indian*	Indus	Indi	Ind.				

NOTES The asterisk in the list indicates that the constellation is a modern grouping, since 1600.

The constellation of Argo has been divided into Carina, Puppis, Vela, and Malus; the last is now usually called Pyxis. In these divisions Argo, the Ship, is most generally known.

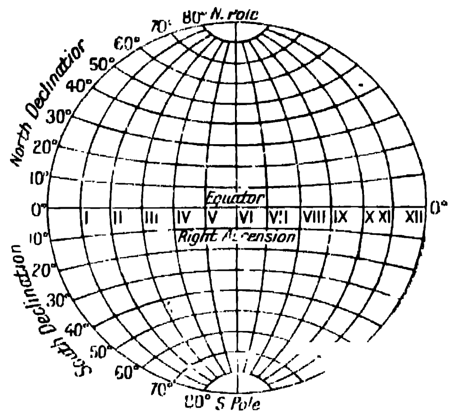
Sobieski's Shield has only recently been generally recognized, Taurus Poniatowski, Sceptrum Brandenburgium, Harpa Georgii, Globus Aethereus (Balloon), Avis Solitaria vel Noctua, Machina Electrica, Officina Tipographica, Telescopium Herschelii, and Honores Frederici, insignificant groups of faint stars with ponderous titles, have been discarded by the International Astronomical Union.

LESSON 23

The Study of Star Maps

To facilitate the recognition of any particular star or constellation, the apparent sphere of the sky is divided by imaginary lines of right ascension and declination, corresponding respectively to terrestrial meridians of longitude and parallels of latitude. The imaginary lines of right ascension—great circles or meridians—pass through the imaginary celestial sphere's two poles (*see* diagram below)

These poles are situated where the axis of the earth, if indefinitely prolonged in both directions, would intersect the celestial sphere, and so they occupy the *zenith of the terrestrial poles*



STELLAR MEASUREMENTS

"zenith" being the astronomical term for the point vertically above the observer's head. The *celestial equator* is a great circle drawn round the imaginary sphere midway between the poles, and it is situated above the earth's equator (*see* diagram on right).

Celestial Meridian Circle

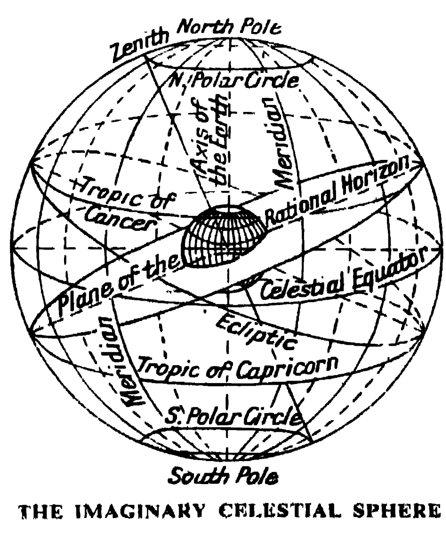
Every place has its own celestial meridian circle, and the rotation of the earth causes this meridian to make a complete revolution of the sky in 24 hours. In the course of this revolution it passes over every visible star, but it is usual to speak of the stars as "crossing the meridian." This occurs when they are due south of the north celestial pole (as seen from these latitudes), and are therefore at their highest altitude above the horizon.

The horizon is usually regarded as the limit of our vision at any particular place, but astronomically it consists of the great circle 90° distant from the zenith of the observer; so observers at different latitudes on earth are bounded by different celestial horizons. The farther south the latitude, the higher is the altitude attained by the stars, and therefore the greater is the number to come within observation. A star's altitude, then, depends upon the observer's standpoint on the earth and also upon the time of observation.

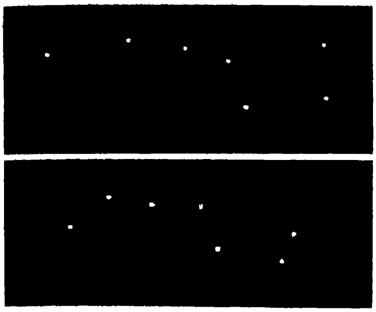
Circle of Perpetual Apparition

There is one star upon which the time of observation makes very little difference—the Pole star, which is nearly above the terrestrial pole and always remains almost at the same altitude according to the latitude of the observer. It is always virtually in the same position; it revolves in a small circle round the exact celestial pole at a distance of only 1° 3½' from it. All the other stars will be seen to bear a permanent relationship to this star, and differ only relatively to the horizon and the observer because of their diurnal revolution and annual progression westwards. But those which are *circumpolar* and revolve N. of the zenith point are within the *circle of perpetual apparition.*

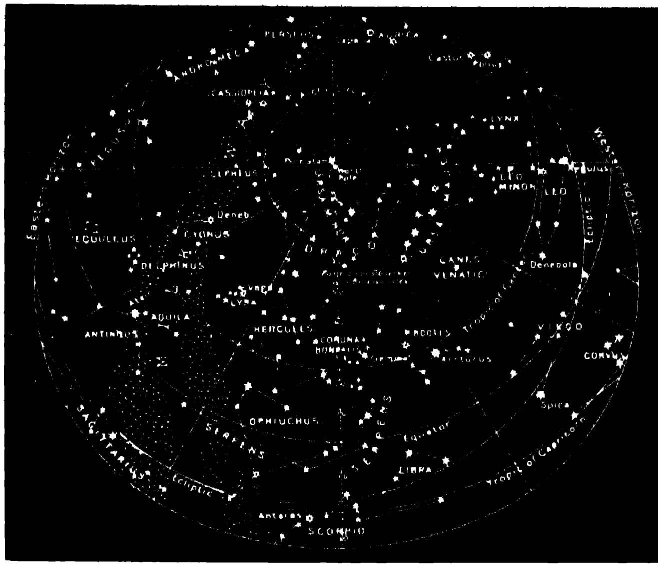
The most familiar of these are the seven bright stars of Ursa Major, commonly called the Plough or Charles's Wain. Two of these stars, α and β, point almost directly to the Pole star or *Polaris*—hence their name, the Pointers. Five of these stars, β, γ, δ, ε, and ζ, together with several smaller ones, constitute a group of suns which are all travelling in the same direction in space, apparently more or less towards Arcturus; α and η are travelling in different directions, with the result that in 50,000 years' time the familiar figure of the Plough will have



THE IMAGINARY CELESTIAL SPHERE



MOTION OF THE PLOUGH. The stars have not only an apparent but a " proper " motion. Thus the familiar constellation of the Plough, or Great Bear, seen as it is to-day, in the upper diagram, will have changed in 50,000 years from now to the shape shown in the lower diagram.



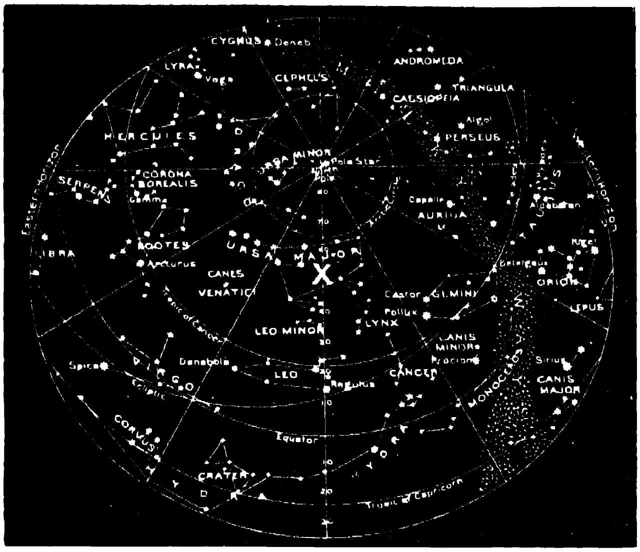
This star map shows the constellations visible at 6 a.m. on February 18 or at 7 a.m. on January 31. The position of an observer in the British Isles is marked both in this and in the map below, a little below the Arctic Circle.

MORNING AND EVENING SKY IN WINTER. In the map immediately above are charted the principal stars visible at 6 p.m. on February 18 or at 7 p.m. on January 31. The Milky Way, vertical in the early morning (see top map), now stretches horizontally across the sky.

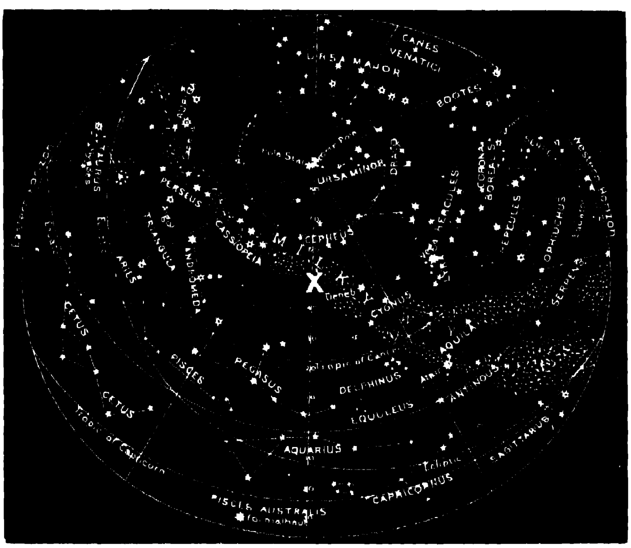
changed. The Plough is about overhead in the spring evenings and low down in the north below the Pole star in the autumn.

On the opposite side of the Pole star to the Plough are the five stars of Cassiopeia, arranged somewhat in the form of a W, which, with a fainter sixth star κ added, constitute Cassiopeia's Chair. These constellations occupy two quadrants of this circumpolar area. Two very bright stars, together with several easily remembered of lesser brilliance, comprise the constellations of Auriga and Lyra. The brilliant Capella and β Aurigae of the former are almost overhead in the winter evenings, and Vega and the two stars β and γ Lyrae below it are nearly overhead late in the summer evenings. Vega is low down in the north in winter evenings, and Capella occupies this position in summer evenings.

Among the less prominent stars is the constellation of Draco, the celestial Dragon, which is between the zenith and the Pole star on summer evenings ; Cepheus is in this position on autumn evenings, with the brilliant Deneb of Cygnus, the Swan, commonly called the Northern Cross, nearly overhead. Deneb is also within the circle of perpetual visibility, although the Cross is not ; it is a sun of exceptional intrinsic brilliance, radiating 10,000 times the light of our sun, but from a distance 41,140,000 times as great, and having an absolute magnitude of $-5{\cdot}2$. Deneb is the most brilliant sun of the northern heavens. As if they were swinging round the north celestial pole are the seven stars of Ursa Minor, the Little Bear. These remotely resemble in arrangement the seven stars of Ursa Major, but only Polaris and the "Leaders" are bright—Polaris at the tip of the



In this map are shown the positions of the principal stars visible at 10 p.m. on March 21 or at 8 p.m. on April 22. In all four of these maps the stars of each constellation have been joined by lines to facilitate their recognition.



THE HEAVENS IN SPRING AND AUTUMN. **A map of the sky as an observer would see it at 10 p.m. on September 21 or at 8 p.m. on October 23. The ecliptic indicates the annual path of the sun and the approximate paths of the moon and planets. X indicates overhead point.**

Bear's tail, β and γ between it and the Plough handle. They are north of Polaris in winter evenings, east in spring, south in summer, west in autumn. Apart from these circumpolar, always visible stars, most of the starry host appear to pass before us as a diurnal procession from east to west between the zenith and the southern horizon; all, that is, except those perpetually hidden because they encircle the south celestial pole. As the earth's rotation successively brings into view all these stars in 24 hours, it would be possible to see the entire concourse were it not that the sunlight obscures about one-half of them during daylight hours. As the earth revolves in its annual orbit the other half of the starry heavens comes into view.

In the sky, stars appear as if projected upon a dome, but star maps, such as those shown here, present them on a flat surface with resultant distortion of relative positions. There the lines of right ascension have to appear as if radiating from the pole in straight lines instead of arcs of great circles. Those of declination are indicated by the degrees close to the central meridian.

The right ascension of a star is the angular distance between the great circle which passes through that star and the pole, and another great circle passing through the pole and a fixed point on the celestial equator called the vernal equinox or the First Point of Aries. Right ascension is always reckoned from this equinox in an easterly direction round the equator, which is divided into 360°. As the celestial sphere appears to make one complete revolution in 24 hours, a meridian passes over 15° in every hour. It is usual, therefore, to reckon right ascension not in degrees but in hours, minutes, and seconds.

One hour of time or right ascension is equal to 15°, one minute of time to 15 minutes of angular measurement, one second of time to 15 seconds of angular measurement. This is expressed in symbols thus: 1 hr. = 15°, 1 min. = 15′, 1 sec. = 15″. As the position of a geographical place is stated as being situated in, say, latitude 51° 30′ and longitude 10° 15′, so the position of a star—e.g. Sirius—is stated as right ascension 6 hr. 40 m. 42 sec., and declination −16° 35′ (the minus sign indicates south declination, and the plus sign indicates north declination).

LESSON 24

Stellar Magnitudes and Distances

THE visible stars are classified according to their apparent brightness in a series of magnitudes which have no relation to their real or, as it is called, *absolute* magnitude. Thus a faint star of the fifth magnitude may actually be larger and brighter than one of the first magnitude, its apparent faintness being due to its much greater distance.

The apparent magnitudes visible to the naked eye range from first down to sixth. The latter are the faintest to be perceived on a clear, dark night, in the absence of any artificial aid. Each magnitude is about $2\frac{1}{2}$ times brighter than the next. This *light ratio*, calculated to be 2·512 times that of the magnitude below it is chosen so that a difference of five magnitudes represents a ratio of brightness of 100 to 1. Below the sixth are the telescopic magnitudes; these extend down to the 20th magnitude for stars observed visually, 21st for stars perceptible photographically, and 22nd for those perceptible photoelectrically.

Visual and Photographic Magnitudes

As distinct from photographic magnitudes, visual magnitudes are based on the *light-ratio* scale, and the extent to which a star's light is below either of the standard magnitudes is indicated by decimals as, for instance, Antares, which is 1·22, or a little more than one-fifth, below the standard first magnitude. There are a few stars brighter than this standard; they are measured from zero, as, for example, Capella, which is 0·21 magnitude or just over four-fifths brighter than the standard first. There are two stars brighter than even zero; these are Sirius and Canopus, which have a negative magnitude rendered thus: Sirius −1·58, Canopus −0·86, the figures being preceded by the minus sign. On this scale, the sun is a star of magnitude −26·7, while the moon's magnitude is −11·2.

Photographic methods of determining magnitudes have produced a somewhat different scale from the visual. Stars of different brightness produce dots of different size on the photographic plates, and this is used to determine the magnitude. By lengthening the exposure, the light of very faint stars, invisible to the eye through even the highest powers of the telescope, becomes imprinted on the photographic plate as a result of the accumulation of the star's light.

Because the photographic plate is relatively more sensitive to the blue end of the spectrum, if a blue star and a red star of equal visual magnitude be photographed, the blue will appear much brighter on the plate. The difference, photographic minus visual magnitude, is known as the *colour-index*. By using a yellow filter with isochromatic plates, a magnitude scale corresponding very closely with the visual has been obtained; such magnitudes are called *photo-visual*.

The accompanying table gives the number of stars within each standard magnitude; those below sixth magnitude are according to the estimates of Seares and van Rhijn. The brighter magnitudes are subject to different estimates owing to the number of stars whose brightness varies; the number of the telescopic stars is calculated from sample counts taken over certain areas.

STARS OF STANDARD MAGNITUDES

Standard Magnitude	Number of stars calculated according to *Photographic magnitude*	*Visual magnitude*
Above 1·5	20	20
From 1·5 to 2·5	38	41
2·5 to 3·5	111	138
3·5 to 4·5	300	454
4·5 to 5·5	950	1,480
5·5 to 6·5	3,150	4,750
6·5 to 7·5	8,200	14,300
7·5 to 8·5	22,800	41,000
8·5 to 9·5	62,000	117,000
9·5 to 10·5	166,000	324,000
10·5 to 11·5	431,000	870,000
11·5 to 12·5	1,100,000	2,270,000
12·5 to 13·5	2,720,000	5,700,000
13·5 to 14·5	6,500,000	13,800,000
14·5 to 15·5	15,000,000	32,000,000
15·5 to 16·5	33,000,000	71,000,000
16·5 to 17·5	70,000,000	150,000,000
17·5 to 18·5	143,000,000	296,000,000
18·5 to 19·5	275,000,000	560,000,000
19·5 to 20·5	505,000,000	1,000,000,000

It is usual to include in a given magnitude all stars with 0·5 above or below the standard magnitude, as indicated in the table. There are, in addition to this estimated number of visible stars, immense numbers more, which will be revealed as higher powers of the telescope are effected. It has been estimated by Seares and van Rhijn from several considerations that the total number of stars reaches the colossal figure of about 30,000,000,000.

Stellar Distances

The tremendous distances of the stars afford the next most astounding fact. The remoteness of even the nearest is arrived at by means of their *annual parallax*; that is, the apparent position of the nearest stars changes relatively to that of the more distant ones in consequence

of the earth's annual change of position in its orbit round the sun. The difference in the star's apparent position is very slight, and depends upon the side of the earth's orbit from which we are looking.

This represents an annual translation of about 186,000,000 miles, say, between midsummer and midwinter, and produces a different perspective in the apparent relation of one star to another; the difference is much less for the more distant stars, until a point is reached at which any change is imperceptible. The limit at present is 0·01 of a second of arc. Thus only a limited number of stars can have their distance measured by this method, in spite of the immense length of the base-line subtended by the earth's orbit.

The annual parallax of a star is therefore equal to the angle which would be subtended at that star by the radius of the earth's orbit; but there is no star in whose case this parallax would amount to as much as a single second of arc. The great difficulty of measuring quantities of this nature is obvious. Delicate instruments and refined handling are necessary, together with numerous measured observations, the parallax shift having to be disentangled from the star's own *proper motion* through space.

Stellar distances are so gigantic that astronomers are forced to represent them in terms of some different unit from that ordinarily used. Miles become meaningless, for the nearest star is about 270,000 times farther away than the earth is from the sun, which means that it is about 25,110,000,000,000 miles away. Suppose we take the sun's distance, which is the *astronomical unit* of 93·0 million miles, and represent this by a foot, the sun would then be, in proportion, a tiny sphere $\frac{1}{8}$ of an inch in diameter, the earth a scarcely perceptible speck of dust, while the nearest star on this scale would be about 50 miles away.

To represent the distance of a star in terms of parallax, this would have always to be expressed in small fractions of a second, which would vary inversely as the distance. This inconvenient method has been overcome by the institution of the *parsec*. This represents the distance at which the radius of the earth's orbit would subtend an angle of one second of arc, expressed as 1″. Thus the *par*allax and one *sec*ond make the standard *parsec*, which is 206,265 times the sun's distance, the astrononomical unit, and represents about 20,000,000,000,000 miles. A *kiloparsec* represents 1,000 parsecs, a *megaparsec* represents a million parsecs.

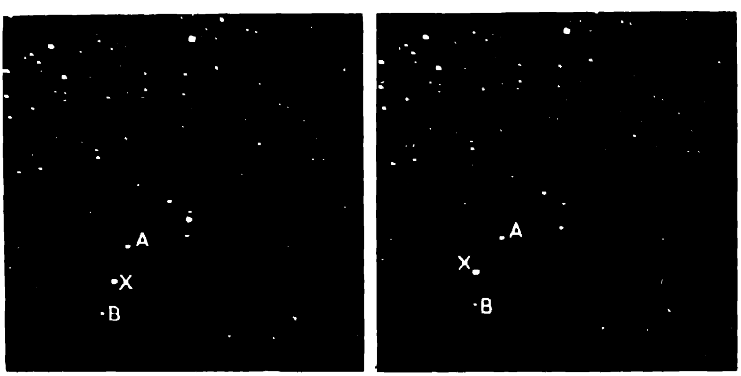
An older and more popular unit of measurement is the *light-year*, which represents the distance light travels *in vacuo* at 186,271 miles per second, according to the accepted standard of Michelson. Light travels from the sun in a little over 8 minutes, or 499 seconds; it travels 63,290 times the sun's distance (i.e. astronomical units) in a year. This is a convenient standard, easily grasped, hence its extensive use. There are 3·26 light-years in a parsec; more precisely, a light-year is 0·3069 of a parsec.

If a star were at a distance that caused its apparent annual shift or parallax to amount to 1″, or one parsec, this would equal 3·26 light-years; so to find the distance of any star from its parallax this simple formula can be used:

$d = \frac{3 \cdot 26}{p}$ where d is the distance in light-years and p is the parallax.

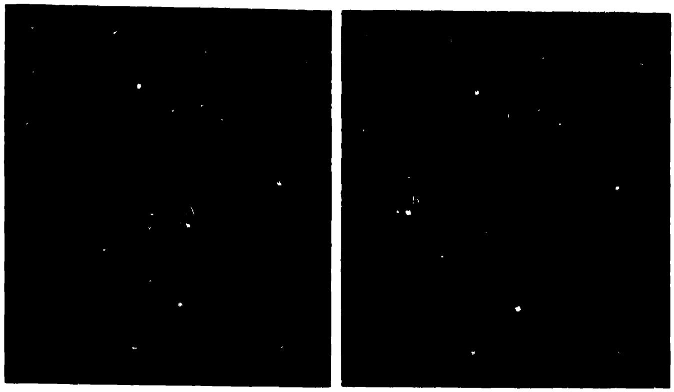
The necessary observations had originally to be taken visually, and it was thus that Bessel in 1838 measured for the first time the distance of a star. This was 61 Cygni, a small double star which, from its relatively rapid *proper motion*, led him to suspect that it was one of the nearest; it proved to be 10 light-years distant. Soon after Bessel's discovery Henderson, at the Cape of Good Hope observatory, found that the bright star Alpha Centauri was at 3 light-years' distance; it is now known to be about $4\frac{1}{4}$ light-years.

The photographic method of obtaining parallaxes was introduced by Professor Pritchard, of Oxford, in 1886; instead of laborious



MEASURING THE DISTANCE OF THE STARS. These diagrams show an accurate method of determining star distances. A photograph (left) of a portion of the heavens is taken through a powerful telescope at the beginning of a six-month period. A second photograph taken at the end of the period, when the telescope has been carried by the earth to a point 186 million miles distant, shows an apparent movement of the star marked X relative to those marked A and B and the fainter stars in the background. Calculations based on this difference give the star's distance in parsecs. Note that the star pattern in the background remains unaltered, so remotely distant are its components.

observations, photographic plates are exposed when the earth is at opposite sides of its orbit. The observations have to be made at the same hour-angle to avoid varying effects of refraction and atmospheric dispersion. Thirty or forty plates are now taken, the comparison stars having to be measured too for proper motion, and in case any of them are near enough to have an appreciable parallax. Stars showing a parallax of only 0·005 of a second, which represents about 650 light-years, can now be measured with a fair degree of accuracy; beyond that, errors of observation become comparable with the quantity sought.



PROPER MOTION OF THE STARS. A way of determining proper motion of an individual star is shown in these diagrams. The star at A, in the photo on the left, taken at Cambridge Observatory in 1903, is Groombridge 34, a double star with a large proper motion. From photographs taken 23 years later, this proper motion was accurately determined, so that it is possible (right) to estimate the position (B) the star will occupy 500 years hence. The proper motions of the other stars are relatively small.

Although the stars are apparently fixed, they have a real motion of their own in addition to the apparent diurnal motion due to the earth's rotation, and the apparent annual motion across the sky, as a body, due to the earth's revolution round the sun. This, as pointed out earlier in this Lesson, produces yet another motion, apparent only in stars sufficiently near—the minute ellipse which they appear to perform relative to the more distant stars.

Stellar Motions

In addition to these apparent motions the stars change their positions slightly from year to year; this is called their *proper motion*. It is imperceptible to the naked eye, even during a lifetime, but is very apparent in modern instruments of precision. There are two ways in which this motion can be measured. One is by the actual displacement of the star on the celestial sphere—but most of this is found to be due to *precession*, *nutation*, and *aberration*, which are also due to terrestrial influences and are shared by all the stars in any particular section of the sky.

After all these minute quantities have been allowed for, there remains the gradual shift of each star relative to the others. Not many more than a hundred stars are known which thus move a second of arc or more in a year. So small an amount is this that it would take about 2,000 years for a star with such a proper motion to move over a distance equal to the apparent diameter of the full moon. It was discovered by Halley, 200 years ago, that Sirius had travelled southward to about this extent, that is, half a degree, since the time of Ptolemy.

A large proper motion is generally an indication that the star is among the nearest to us and therefore likely to reveal a parallax when measured. If such a star is at a known distance from the earth or, as it is usually reckoned, from the sun, then it becomes possible to calculate the star's actual velocity. It is necessary to know also its radial velocity, to be obtained from the angle at which the star is travelling relative to the line of sight. Thus a distinction must be drawn between the star's apparent angular rate of motion and its actual velocity, since a star travelling direct towards us in the line of sight would possess no perceptible proper motion.

Doppler's Principle

The spectroscope has enabled astronomers to solve this problem, to measure a star's motion in the line of sight and decide whether it is approaching or receding, with remarkable accuracy. This is in virtue of *Doppler's principle*, which briefly is as follows.

Each of the series of lines in the spectrum has a precisely defined place according to the gas from which it originates; this is due to the fact that light of any particular wavelength is refracted to a certain definite extent. Suppose the source of the light is a star travelling towards the spectroscope, the light which it emits will reach the spectroscope with its own speed added to that of the star. Consequently a greater number of light waves per second will reach the refracting prism of the spectroscope than would be the case if the star were at rest, while a lesser number of light waves will arrive if the star be receding.

Thus there is revealed a shift in the lines in the spectrum through a distance which, though very minute, is capable of being measured with sufficient accuracy to show the direction and extent of stellar velocity. If the star is receding,

the lines will be shifted toward the red end of the spectrum; if it is approaching, the lines will be shifted toward the violet end. Thus is the *radial velocity* obtained.

The speed of stars was thus obtained, visually at first, by Huggins in 1867. For the last 80 years photographic records of the star's spectrum have replaced the visual, and the *radial velocity* of several thousand stars is now known. This, together with the star's angular *proper motion*, which gives by a simple calculation the star's *tangential velocity*, enables its actual speed to be calculated and also the direction in which it is travelling.

It is found that the stars generally appear to be speeding in different directions, though there are some which form groups and travel like a vast flock all in one direction. There is no such thing as rest in the universe, for all the bodies within it are travelling at immense speeds. Our own sun is moving at the rate of about 12½ miles per second towards a certain point, called the solar apex, in the constellation of Hercules at approximately right ascension 270°, or 18 hours, and declination +31°.

An effect of this motion is to cause the stars to open out in the direction of the sun's motion and to close in toward the *antapex* or opposite point. Sir William Herschel noticed this effect, and concluded that it was caused by the motion of the sun and, of course, the whole solar system, which is travelling through this never-ending stellar vista.

Absolute and Apparent Magnitude

The *absolute magnitude* of a star may now be arrived at, once its parallax, i.e. distance, and *apparent magnitude*, is known. It thus becomes possible to deduce the brightness and real magnitude a star would present if it were removed to a standard distance. If all stars were at this standard distance, then apparent magnitude would represent their absolute magnitude; but they are, in fact, at vastly different distances.

While a star's absolute magnitude may be computed from its apparent magnitude, it is necessary to have some standard of comparison. The sun used to serve this purpose as magnitude 0·0, but since 1922 the standard has been defined by the International Astronomical Union as the magnitude a star would have if it were at a distance of 10 parsecs, which corresponds to a parallax of 0·1″ and represents about 33 light-years. The absolute magnitude M is therefore expressed in terms of the apparent magnitude m, and parallax p, in seconds of arc thus: $M = m + 5 + 5 \log p$.

We may thus visualise our sun, which is the nearest star and has an apparent magnitude of −26·6; but at a distance of 10 parsecs or 33 light-years this would be reduced to +5·0 of apparent magnitude: it would be classed as about fifth magnitude and be visible only as a faint star. Since Vega, for example, at a distance of 8·1 parsecs, and Capella at 13·5 parsecs appear as brilliant first magnitude stars at this distance, it becomes obvious how much greater their absolute magnitude must be as compared with the sun, Vega being 0·6, and Capella much greater, with −0·4. The minus sign indicates that it is above the standard 0·0, and therefore the greater the − magnitude, the greater is the luminosity; the greater the + sign, the less is the luminosity and the smaller the absolute magnitude.

It is possible to determine the absolute magnitude of a star without previous knowledge of its parallax. Differences in the intensities of certain lines of the spectra of dwarf stars, as compared with corresponding intensities of certain lines of giant stars' spectra, had long been noticed; it was found from an investigation of individual stars whose parallax, and therefore absolute magnitude, was known that there was a relation between the intensities of the lines and the absolute magnitude of the stars. A calibration curve of intensities was constructed from numerous stars of known parallax and absolute magnitude, and from this it became possible to deduce the absolute magnitude of numerous stars of *unknown* parallax simply by comparing the relative intensity of the particular lines in their spectrum with those of the standardised curve of spectroscopic intensities for various absolute magnitudes. This done, it became possible to determine a star's parallax from the absolute magnitude thus obtained. Parallaxes obtained by this method are termed *spectroscopic*.

LESSON 25

The Light of Stars, and their Spectra

Most of the knowledge concerning the stars has been obtained by analysing the light they emit. This light varies enormously both in quantity and character. Luminosity as observed visually is no absolute criterion of the particular star's mass or immensity, since a relatively small mass may accompany an immense volume and a surface of comparatively poor luminosity—in which case a relatively small star of great luminosity will far outshine its much greater rival. These differences are associated with their surface temperatures.

The luminosity of the stars has been precisely ascertained from their distances and absolute magnitudes. This luminosity is usually expressed in terms of the sun by the symbol ☉. The differences are tremendous, the most luminous, as far as is known, being Canopus, which has been calculated to radiate 91,000 times the light of the sun, but from a distance of 652 light-years. Proxima Centauri, which happens to be the nearest known sun to our own and which is invisible except through powerful telescopes, radiates 11,000 times *less* light than our sun. Proxima Centauri is a small sun which appears to have nearly "burnt itself out"—exhausted its luminous radiation.

Canopus has the greatest absolute magnitude of 7·4; Rigel, a brilliant star which radiates 18,000 times the light of the sun, follows with −5·8. Sirius, which owing to its proximity appears the brightest star in the heavens, with an *apparent* magnitude of −1·58, radiates only 30 times more light than our sun; its *absolute* magnitude is +1·3.

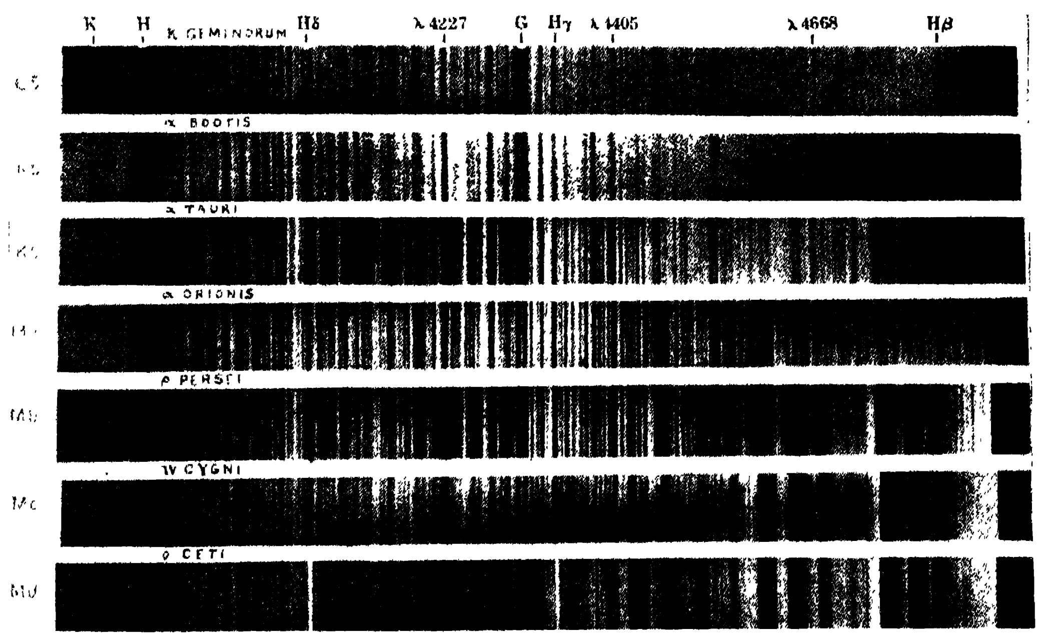
Even to the naked eye the stars exhibit different colours, from the reddish Antares and Betelgeuse to the orange Arcturus, the pale yellowish Capella, brilliant white Sirius and Vega, the bluish Rigel and some other Orion stars. Spectroscopic study of these differences in light has revealed astonishing differences in the surface conditions and in the constitution of the stars. The tints indicate different spectra.

A spectroscopic analysis has been made of about 250,000 stars. The spectra have been arranged in *classes*, each designated by a letter; O, B, A, F, G, K, M, N, R, and S. They were originally in alphabetical order, but subsequent discoveries have necessitated the changed sequence. Since these types blend one into another, various subdivisions by decimal numbers are used, such as B2 and B5, the latter indicating a star of spectral *type* midway between the *classes* B and A. Subdivisions are also indicated by letters, for example, Oa, Ob, Ma.

Continuous Emission Spectrum

This classification, while indicating a spectral type, reveals at the same time a period in the life of a star or sun when it is at about a certain surface-temperature and in a definite known physical condition perhaps linked with either youth or age. The light when analysed is seen to consist of a continuous emission spectrum, upon which appear different lines of absorption characteristic of the various spectral classes. The lines of hydrogen appear in all, but the lines of other elements appear with different intensities in each spectral class, and are variously absent in certain classes.

Class O spectra consist of bright bands superimposed upon a faint continuous background. This class includes the Wolf-Rayet stars. New or temporary stars which suddenly blaze up



TYPICAL STAR SPECTRA. About a quarter of a million stars have been spectroscopically examined and their spectra arranged in classes. These classes are fully described in the accompanying text.
Photos taken by Curtiss at Michigan, with 37½" Reflector

and then die down to faintness also frequently belong to it, when they are expressed as either Oa, Ob, or Oc. The subdivisions Od and Oe represent spectra which contain dark lines chiefly of hydrogen, ionised helium and ionised calcium. The star λ Cephei is typical of these. The surface temperatures of stars of class O are considered to range between 35,000° and 40,000° Centigrade; Novae (new) or temporary stars doubtless reach much higher temperatures. Thus the bluish-white class O represents the hottest type of star known.

Class B spectra contain only dark lines, chiefly of helium. Stars in this class are called helium stars, being mainly enveloped in incandescent helium, together with ionised oxygen and nitrogen. Surface temperatures range from about 23,000° C. for class B0 to about 15,000° C. for sub-class B5. Several of the stars of Orion, including δ, ϵ, and ζ of the "Belt," are of class B0. Achernar and δ Persei are notable examples of B5 sub-class.

Class A spectra exhibit very intense hydrogen and increased calcium lines; magnesium and numerous lines of ionised metals appear in A5. Surface temperatures range from about 11,000° C. for A0 to about 8,500° C. for A5. Sirius and Vega are good examples of A0 stars and Altair of the A5 sub-class. All are white.

Class F spectra display a great increase in the intensity of the metallic lines and a decrease in those of hydrogen. Surface temperatures of about 7,500° C. are attained for F0, to which class Canopus belongs. The temperature declines to about 6,500° C. for F5. Procyon is a good example.

Class G spectra have numerous metallic lines present, together with reduced hydrogen lines. Those of iron and ionised calcium are very strong, and there is a band representing a carbon compound. Surface temperatures are about 6,000° C. for class G0, to which our sun and Capella belong. For the intermediate class G5 the surface temperature declines to about 5,500° C. The stars μ Cassiopeiae and κ Geminorum are of this class. All G-type stars are yellowish owing to the greater intensity at the red end of the spectrum.

Class K spectra are noteworthy for bands due to the presence of hydrocarbons; surface temperatures are about 4,200° C. Arcturus is a good example of "giants" of this type. In the intermediate class K5 bands due to titanium oxide appear, and there is a reduction of temperature to about 3,400° C. K stars are orange, deepening to K5.

Class M spectra exhibit broad absorption bands with low-temperature metallic lines intense, and solar lines faint and few in number; titanium oxide bands become strong and increase towards the intermediate classes M5 and M8. Surface temperatures range from about 3,000° C. for M0 to about 2,700° C. for M5. Betelgeuse and Antares are typical examples of M0 class. This type have a reddish-orange tint. The subdivision class M8e have spectra similar to M8 but with *bright* hydrogen emission lines, a remarkable feature peculiar to long-period variable stars; Mira or o Ceti is a notable example. Temperatures vary between 2,300° C. and 1,700° C.

Class N spectra have broad absorption bands very intense at the red end of the spectrum; these are caused chiefly by the presence of carbon monoxide and cyanogen. All stars of this class are small and very red, owing to the absence of violet in the spectrum. They are apparently "dying suns," and the surface temperatures are low—about 2,600° C. The star 19 Piscium is typical of this class.

Class R spectra are similar to class N, but with the cyanogen band very intense. These stars, though very faint, are not so red as N, and have surface temperatures of about 2,300° C.

Class S spectra exhibit bands of zirconium oxide and strong low-temperature lines, indicating that they are not much above 2,000° C. They are faint and red, all telescopic, and mostly variable stars of long period.

It will be seen from this short survey that the stars decrease in temperature through a well-defined series of gradations indicated by their spectra. That the details of the spectrum reveal the temperatures and therefore the conditions existing on each star or sun has been proved from laboratory experiments in physics. But because, for instance, B stars exhibit a spectrum rich in helium lines and A stars one well supplied with hydrogen, it does not follow that these elements are exceptionally plentiful in such stars. It means that these stars are in that degree of incandescence which causes these elements to be prominent in their spectra.

There is good reason to think that most stars are composed basically of the same elements mixed in roughly the same proportions: if a B star, then, were cooled from 20,000° C. to 3,000° C. its spectrum would resemble type M without any apparent change of chemical composition.

Older theories did, in fact, postulate that stars evolved in this way. This now seems unlikely: a star like the sun keeps shining by converting the hydrogen in its interior into helium by a process akin to that of the hydrogen bomb. When this hydrogen is exhausted, the body probably will not, in cooling, become progressively redder, but is likely to collapse into a state of very low luminosity not represented in the sequence of spectral types we have outlined.

LESSON 26

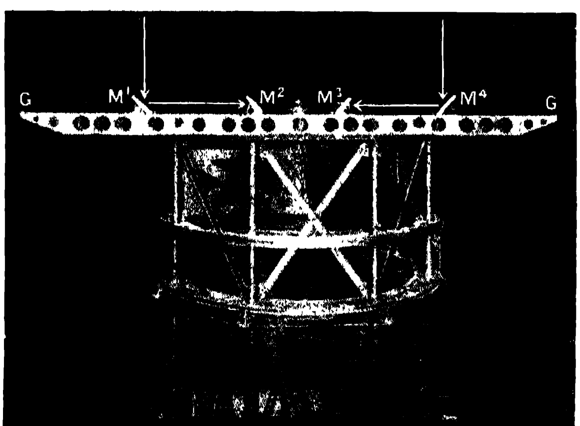
Calculating the Size of Stars

We have seen how the distance, magnitude, and temperature or colour index of a star are arrived at. From these a fairly accurate conception of its size can be estimated. Where it has subsequently been possible to measure giant stars, the calculated dimensions have been found remarkably in accord with the measured diameters.

When the intrinsic brilliance of a star's surface is known, its total output of luminous energy will depend upon the area of surface presented, a large surface pouring out a much greater amount than a small one. This can be measured mathematically; thus, when it and the star's distance, colour index, and temperature are known, the star's size can be calculated.

Stellar Interferometer

It is known that our sun, whose size has been precisely measured, has a certain absolute magnitude, and from this its apparent magnitude at certain distances can be calculated; so any other star possessing a similar spectrum and absolute magnitude, at the same assumed distance, will be of similar proportions to the sun. Any variations therefrom, either as to spectra, absolute magnitude, or distance, become a sure indication of the size of a star by comparison with the sun. It is therefore usual to express a star's radius in *radii* of the sun, the sun's radius being 432,000 miles.



INTERFEROMETER FOR MEASURING STARS. In this combined photograph and diagram the star's light, as shown by the arrows, reaches the plane mirrors M1 and M4 direct from the star; it is then reflected on to plane mirrors M2 and M3. From these it is projected down the long open tube of the telescope in two slender beams to the 100-inch mirror, whence the beams are passed to the focus of the eyepiece in the usual manner.

Measurement of the angular diameter of the larger stars, if not too distant, has become possible by means of the stellar interferometer. This is a most ingenious appliance—developed by A. Michelson (1852 1931), originally conceived by Fizeau in 1868—which can be attached to great telescopes.

Interference Fringes

By means of four plane mirrors placed at M1, M2, M3, and M4 in the illustration below, the capacity of the telescope becomes greatly increased by the two outer mirrors M1 and M4, which are placed at an angle of 45 to the horizontal, reflecting the light of the star to the two inner mirrors M2 and M3, which are also at an angle of 45 and are so placed that the star's light is thence sent down the tube of the telescope to its great concave mirror.

Thus two beams or "pencils" of light from the star reach the condensing mirror, which passes them on to the focal plane of the eye-piece. The effect is to produce a series of interference fringes across the star image, and at a certain but varying distance apart of the plane mirrors M1 and M4 these interference fringes can be caused to disappear. The *distance apart of these two plane mirrors bears a definite and measurable relationship to the angular diameter* of the star under consideration.

The smaller the angular diameter of the star to be measured, the greater is the telescopic aperture necessary, to effect this, the two outer plane mirrors M1 and M4 are placed farther apart, the two inner ones M2 and M3 remaining at a distance of four feet, the two pairs of mirrors being equidistant from the long axis of the telescope.

Changes in the distance are effected by a long girder (G), which is placed across the end of the open tube of the telescope; along this the plane mirrors M1 and M4 can be moved to its full extent Thus it becomes possible to have the equivalent of a telescope over 20 feet in diameter for the production of the interference bands, which is all that matters in this case, but not, of course, for normal observation.

When Betelgeuse had this interferometer applied, it was found that the interference fringes produced by the two beams of light vanished when the plane mirrors were 10 feet apart. Mathematical calculations based upon a standard derived from the known angular distances apart of certain double stars, notably Capella, gave for Betelgeuse the angular diameter of 0·047 of

a second of arc, an amount beyond possibility of measurement by direct vision because of the minute spurious disks presented by the stars when observed telescopically.

Colossal Suns

At the distance of Betelgeuse, that is, 58·80 parsecs or nearly 192 light-years, this angular diameter of 0·047″ would represent an actual diameter of 300 times that of the sun, or 259,200,000 miles. Thus Betelgeuse was found to be a colossal sun with a diameter much larger than the earth's orbit ; if the earth were as near to the centre of Betelgeuse as it is to the centre of our sun, it would be 123,000,000 miles below the surface of that giant sun. It has long been known to vary irregularly in its brightness, and the foregoing measurement was taken near its maximum. Since then, the star having become less brilliant, it was remeasured ; it required a spacing of 14 feet between the plane mirrors M1 and M4. This proved that Betelgeuse now had an angular diameter of 0·034″, and had therefore shrunk to 210 times the sun's diameter, or 181,440,000 miles. Thus the irregular variations in the light of the " pulsating suns " was proved to be due to expansion and contraction of the bodies in question.

Subsequent Measurements

Arcturus, another giant sun, required an extension of the interferometer to 24 feet before the interference fringes vanished. This spacing indicated an angular diameter of 0·020″, which at the distance of Arcturus, that is, 12·50 parsecs, represented a diameter 27 times greater than that of our sun, or 23,382,000 miles. Aldebaran also gave an angular diameter of 0·020″, but owing to its greater distance of 17·54 parsecs this represented an actual diameter 38 times that of the sun, or 32,928,000 miles.

Aldebaran belongs to the gK5 class, while Arcturus is gK0 ; the letter g prefixed to the class signifies " giant," to distinguish them from the " dwarf " types, which, exhibiting similar spectra, are intrinsically far less luminous.

Antares is another of these colossal suns which have already been thus measured. It required a spacing of 12 feet between the plane mirrors ; from this was calculated an angular diameter of 0·040″, actually less than Betelgeuse. But Antares is much farther off, and at a distance of about 38·5 parsecs ; therefore this angular diameter represented the stupendous actual diameter of about 232 times that of the sun, or nearly 200,000,000 miles.

Subsequent measurements revealed that α Herculis, also known as Ras Algethi, was still more stupendous, with a diameter of about 346 million miles, or nearly 400 times the diameter of our sun. Great though this is, it is probable that Canopus far exceeds it, for Canopus radiates 91,000 times more light than our sun as compared with a maximum of only 620 times for α Herculis.

ε Pegasi, or Enif, is another giant sun more recently measured and found to have a diameter of 86 million miles. It is at a distance of 53 parsecs, and radiates about 235 times the light of our sun.

α Ceti, or Menkar, with a diameter of 97 million miles, radiates about 75 times the radiance of our sun and from a distance of 33½ parsecs.

γ Aquilae, or Tarazed, with a diameter of 43 million miles, radiates only about 125 times the light of our sun and from a distance of 43½ parsecs.

Dwarf Stars

The dwarf type of star, to which our sun and indeed most stars belong, is much more massive in proportion to its volume than these giants. Owing to the smallness of their angular diameter it will not be possible to measure most dwarf stars unless the spacing of the interferometer plane mirrors can be greatly extended.

There remains, however, the method of *calculating* diameters (already described). In the case of those stars which it was subsequently found possible to measure, it was seen that the calculated diameters were remarkably in accord with the measured diameters ; e.g. Arcturus, calculated to have an angular diameter of 0·023″, was found by interferometer measurement to be 0·020″; Betelgeuse was calculated to be 0·048″, while the interferometer revealed it as 0·047″; and Antares, calculated as 0·042″, proved to be 0·040″. The calculated diameters are as follows for the most prominent stars, in proportion to the sun: Sirius, 1·8 times ; Vega, 2·4 ; Altair, 1·4 , Procyon, 1·9.

Sub-dwarfs

These are the ordinary dwarf or main-sequence stars, far more common in space than the giants, which force themselves on our attention by reason of their enormous radiating surfaces. Yet more frequent, it is now believed, may be still less luminous stars, called sub-dwarfs, which are difficult to see because they have such small diameters and thus can radiate so little. When the dimensions of these stars are calculated, they are found to be no bigger than planets. There is thus an enormous range in the sizes of the stars, from giants hundreds of times bigger in diameter than our sun to tiny bodies no bigger than Neptune.

LESSON 27

Double Stars and Binary Systems

DOUBLE stars when viewed telescopically are seen to consist of two suns with an angular separation of usually not more than 30″. The first star found to be double was Mizar or ζ Ursae Majoris, when Riccioli noted it in 1650. In 1874 Sir William Herschel, who had for some years been giving close scrutiny to the subject, produced a catalogue with about 700 double stars, describing their relative positions. Now some 30,000 have been catalogued and more are being added every year. This includes numerous triple and some multiple stars.

Optical and Physical Doubles

Because two stars appear close together, they may in some instances be thus seen in the line of sight only, and one component may actually be nearer to us than to the other. When there is thus no physical connexion, they are described as *optical doubles*. When they are connected by gravitational attraction or common proper motion, they are called *physical doubles* or pairs. This is a further and important distinction which originated with Sir William Herschel. By the beginning of the last century he had noted changes in the relative positions of the components of some of the double stars which he had catalogued many years before. The fact was consequently revealed that several pairs were sufficiently close to influence one another gravitationally and so produce orbital motions. To such a star he gave the name of *binary*.

The probability of two stars being binaries when appearing very close together is much greater than that of their being merely optical doubles; this is particularly so if they are both of similar brilliance, or if the brighter component is yellowish and the fainter either greenish, blue, or purplish, in tint. These complementary colours seem to prevail in binary systems, for reasons as yet imperfectly understood by astronomers.

Interferometer Detection of Binaries

A few binaries or double stars are perceptible with good field glasses, and these are examples which are much more than 30″ apart. Nearly all require telescopic aid and usually high powers, because so many appear not more than a second or two apart. A great telescope will reveal double stars down to 0·2″ of separation, and the interferometer has been useful in proving suspected stars to be double. It was, in fact, first used upon the star Capella, which Greenwich observations had indicated as appearing elongated in its spurious disk, thus suggesting that the star might be double; the interferometer not only proved it to be so, but also gave the angular distance apart of the components. As a consequence it has become possible to measure the angular distance of separation between stars down to 0·08″.

Duplicated Spectral Lines

At the distance of many double stars this small amount represents thousands of millions of miles, and even in the case of the nearest it will mean hundreds of millions, but numbers of binaries are much nearer together even than the earth is to the sun. This has been found out by means of spectroscopy; for instance, if two stars close together and of similar brightness are revolving in an orbit appearing more or less edgewise, as seen from the earth, then at certain times one of the stars will be moving along the line of sight towards the observer, while the other star at the opposite side of this stellar orbit will be moving away from the observer. The result will be that the lines of the spectra of each component star will be displaced, upon the same principle, i.e. Doppler's (*see* Lesson 24), as obtained in the case of stars advancing and receding from us.

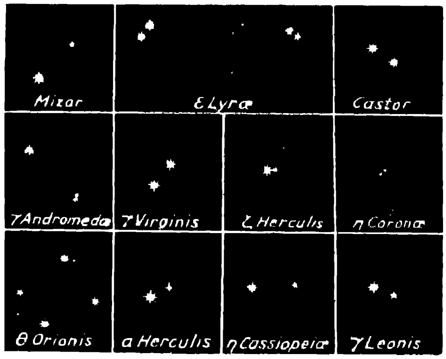
Thus the spectral lines will appear doubled. This appearance is greatest when the perspective presents the stars as widest apart; when both stars are together in the line of sight, the duplicated spectral lines close up and appear single. If there are great differences in the respective magnitudes of the components, or if they are of different spectral types, the problem becomes more complex, but can be accurately solved. The variations are always periodic, repeating themselves at intervals of perhaps a few hours, a few days or sometimes after the lapse of several years

Spectroscopic Binaries

These stars are called *spectroscopic binaries*; over a thousand are known, and from the number tested about one star in five proves to be a spectroscopic binary, on average, though in some spectral classes the proportion is greater, notably the B type of star. A large number of stars must be spectroscopic binaries. The details are obtained photographically from five (or preferably more) spectrograms taken at different times in order to record various positions of the component stars and thus to compute their orbit.

With their parallax known it becomes possible to calculate their mass, luminosity, distance apart, and even their actual dimensions in

miles. It is found that many spectroscopic binaries are composed of suns only a few million miles apart. The first to be discovered, as in the case of double stars, was Mizar of Ursa Major, when Pickering, in 1889, found that the spectrum of the brighter of these two stars possessed lines that were doubled at regular periods of 20½ days. Subsequent research explained the cause, and showed this star to be composed of two suns, 25,300,000 miles apart, with an average orbital velocity of 43 miles a second and revolving in a period of 20·54 days ; their united mass being 1·67 of the sun's with an absolute magnitude of 1·4 at a distance of 22·22 parsecs, or nearly 72½ light-years.



VISUAL BINARIES. Examples of visual double, triple, quadruple, and multiple stars such as are described in the text.

Long and Short Periods

It has been observed that about 56 per cent. of spectroscopic binaries have periods of less than 20 days, and 26 per cent. between 20 and 100 days, the remainder being longer. Of these the most noteworthy is Capella, one of whose visual components, as revealed by the interferometer, is a spectroscopic binary whose suns have a period of 104 days, and a mass somewhat larger than our sun. The star β Arietis is a spectroscopic binary whose suns average about 29,000,000 miles apart, and the period of their revolution 107 days. The brighter star of ξ Ursae Majoris is composed of two suns averaging 36,500,000 miles apart, with a period of revolution amounting to 665 days, their orbital motion averaging only 4½ miles a second. An exceptionally long period is that of β Capricorni, its two suns taking 1,375¼ days to complete the revolution of their immense orbit, the diameter of which averages no less than 470,000,000 miles.

Speed 130 Miles per Second

Noteworthy examples of close spectroscopic binaries with very short periods are the following. Spica Virginis, a brilliant star of the first magnitude, is composed of two suns whose mass is 9·6 and 5·8 that of our sun, and whose distance apart of their centres averages only 7,000,000 miles ; their surfaces must be almost in contact, consequently their period of revolution is only 4 days, the smaller sun travelling over the larger orbit at the terrific average rate of 130 miles a second. ψ Orionis has a period of only 3 days. The components of μ Scorpii revolve in only 1½ days, speeding round their common centre of gravity at the terrific rate of about 300 miles a second. The centres of these suns being only about 7,000,000 miles apart, their surfaces must be close together.

Castor's Suns

Similar details have been obtained regarding *visual binaries*, in which some components have been found to be themselves spectroscopic binaries. Thus stellar systems are gradually revealed to be composed of several suns, some with pairs of almost equal mass and volume like ϵ Lyrae, with two pairs of visual suns and one spectroscopic companion to the brightest of the four ; their periods are hundreds of years in duration. Castor is a splendid example of a multiple system of suns. It is a visual binary whose components -known, as is usual with double stars, as A and B, according to their relative brightness— have a distant companion star known as C. All three, A, B, and C, are spectroscopic binaries with short periods of revolution, thus providing six suns to this multiple system of Castor.

Importance of Double-star Observation

The importance to astronomy of double-star observation is that by this means, and by this means alone, we gain all our knowledge of the masses of the stars. By carefully observing year by year the slow progression of one component round the other under their mutual gravitational attraction, it is possible to map the orbit. If the distance of the binary is known, the scale of this map in miles can be determined , whence, knowing the period, the mass of the system can be calculated in much the same way as the mass of a planet can be calculated once the period and orbit of its satellite are known. In this way the masses of a selection of practically all types of star have been found. They lie between a few tenths and about ten times the mass of the sun.

Thus there is not a great range in the masses of the stars ; and it follows, since there is an enormous variation in their linear dimensions, that they must show astonishing differences in density. The material they consist of ranges from inconceivably tenuous gas, less dense than the best vacuum that can be produced on earth, to material so heavy that a handful would weigh a ton.

LESSON 28

Principal Classes of Variable Stars

Although the great majority of stars shine with a luminosity apparently steady and without perceptible variations, there are between 5,000 and 6,000 known stars whose fluctuations are a characteristic and very instructive feature as to stellar conditions. These are called *variable stars*. There are many types, the different variations in their light being due to different causes. The various peculiarities, in their periods, in their light curves or intensities, and in their spectra, have been closely studied. As a result, distinct varieties and classes, with characteristics common to each class, have been revealed, with minor differences in each class.

Designation of Variable Stars

The four classes are eclipsing variables; short-period variables; irregular variables; and long-period variables. To these are added by some a fifth class, the *Novae* or so-called new stars.

Variable stars are designated by a Roman letter, one from R to Z, which is placed in front of the name of the constellation. Thus: S Persei for Algol, Z Herculis, and Y Cygni. When all the letters down to Z have been applied and there are still more variables in the constellation to be designated, the letters are doubled progressively from RR, RS, RT, and so on to ZZ. This has been reached in some constellations and so is now followed by AA. Thus are obtained TV Cassiopeiae, RT Persei, TX Herculis, and RZ Ophiuchi. No single letters before R are used for this purpose, and no methods are at present adopted to distinguish the four classes.

Eclipsing Variables

The class eclipsing variables consists of *binary* stars whose components revolve at such an angle relative to the earth that the planes of their orbits are presented edgewise or almost so; consequently one or other periodically passes in front of its companion, and there occurs an observed diminution of the light during the time that one is being eclipsed. The resulting variations in magnitude differ according to the relative brightness of the two components and the inclination of the planes of their orbits. When this reaches 90°, the orbits appear as straight lines, and one star passes centrally across the other in eclipse.

Between 200 and 300 eclipsing variables are known. More are discovered each year, mainly through photography of their spectra, because none of the separate components is perceptible visually—even through the most powerful telescopes, in which they always appear as one star; but through the spectroscope their binary character is proved.

Algol's Light

The most noteworthy and easily observed eclipsing variable is Algol or β Persei, also known under its variable star title of S Persei. Algol decreases from 2·3 to 3·7 magnitude in about 4½ hours, during which time a large and much less luminous body passes in front of Algol until the minimum is reached, when only one-sixth the light of the star reaches us. After a few minutes it is seen to be brightening up until after another 4½ hours Algol has resumed its normal brilliance and the obscuring body has passed. The whole process is repeated after an interval of 2 days 20 hours 49 minutes, but about midway between the two minima there occurs a slight diminution of Algol's light; this happens when the bright orb of Algol passes in front of the much less luminous disk of its companion.

Secondary Minimum

This is known as the secondary minimum, and is a frequently observed feature of eclipsing variables, as is theoretically to be expected. These phenomena, together with spectroscopic and mathematical considerations, indicate that Algol consists of two bodies, one very brilliant and radiating about 200 times the light of the sun, while the other is much less luminous and, though nearly as large or perhaps larger, possesses far less mass. Algol is a B type of star, and the distance of its centre from that of its faint companion is, according to Vogel, about 3,250,000 miles.

Another type of eclipsing variable is represented in a bright star by β Lyrae; in this case the secondary minima are much more pronounced, each being separated by two equal maxima. The whole cycle of change takes 12 days 21 hours 47 minutes, and ranges from 3·4 to 4·5 magnitude at greatest minima, and to 3·8 at secondary minima, which occurs exactly midway between the greatest minima. Spectroscopic investigation into this curious variation has shown that it is due to two very ellipsoidal bodies, one much brighter than the other, revolving round a central point of gravity, between two centres, and with their surfaces almost touching. The resultant tidal effect of such proximity is sufficient to account for their oval shape. The brightness of one is about 9½ times greater than that of the other, so when it

is the turn of the brighter one to pass in front of the fainter, the secondary minima occur.

Another bright eclipsing variable is β Aurigae, in which both stars are of nearly equal brightness and size ; in this case the minima are of equal intensity, and the whole cycle of variation is 3 days 23 hours 2½ minutes. Most other eclipsing variables are very faint or telescopic.

Short-period Variables

The short-period variables class consists of stars whose brightness varies in consequence of periodical physical changes in the star itself ; they are therefore true variables. The most important ones are the *Cepheid* variables, from the star δ Cephei, which typically represents them. This star varies between 3·7 and 4·6 magnitude in a period of 5 days 8 hours 48 minutes, so it is easily observable. It is of type gF8, with a mass 10 5 times that of our sun, but with the very low density of only 0 0006 that of our sun. With a mean absolute magnitude of 2·2, δ Cephei is a sun of enormous size. This has been calculated to amount to an average diameter of 22,500,000 miles, or about 26½ times that of our sun.

Spectroscopic and mathematical research has established the fact that the great variations in the light of this star are due to a periodic change in its diameter amounting to about 1,600,000 miles. At maximum this huge gaseous sun has risen to a great increase of surface temperature amounting to about one thousand degrees Centigrade, resulting in an immense increase in light and heat radiation. After this terrific expansion, which occupies little more than a day, it shrinks less rapidly during the course of the next four days to minimum, in preparation for the next outburst of energy. As distinct from the eclipsing variables, the increase from minima to maxima is always much more rapid with Cepheids than is the decrease.

Far-distant Universes

While δ Cephei is typical of short-period variable stars, of which several hundred are known and are being added to every year, there are many variants. The periods of pulsation range from a few hours to about 36 days, though the average is about 7 days. While the light variation usually amounts to about 1 magnitude, it may be nearly half a magnitude more or less. The Cepheids are all giant suns, some attaining 5 or 6 times the diameter of δ Cephei, but they are all of very low density, which is lower in proportion to the increase in the star's diameter and in its absolute magnitude.

A most remarkable "law" has been discovered in regard to Cepheid variables. It is that there is a definite relationship between the star's luminosity and the period of the star's pulsations--the greater the luminosity, the longer the pulsation is the rule. Therefore, when the length of the pulsation is ascertained (an easy matter for the astronomer), the star's luminosity or absolute magnitude becomes known in consequence. By comparing the star's *absolute* magnitude with its *apparent* magnitude, its distance can be calculated.

In consequence of this discovery it has become possible to measure colossal distances far beyond the possibilities of trigonometry and spectroscopy. It applies more particularly to finding the distances of those remote star clusters and spiral nebulae, now known to be far distant universes, in which Cepheid variables have been found, their observed length of pulsation as compared with their faintness recording their distance, and therefore that of the particular star cluster or spiral nebula in which they are placed.

Certain varieties of short-period variables, such as RV Tauri, have light curves which suggest that they may be composed of two bodies very close together or in a state approaching fission, in which the variations in their light would be produced largely by their rotation and tidal oscillations, thus accounting for the complicated light curves.

Long-period Variables

The long-period variables class exhibits periods of variation ranging from about 150 days to 400, though a few of the stars belonging to it extend to 600 days ; rarely are they less than 150. There is thus a wide separation from the Cepheids and eclipsing variables. In the long-period variables the variation is very great, often amounting to a difference of 9 magnitudes.

A typical example is the easily observed o Ceti, or Mira, the "Wonderful." It was known from ancient times, but Fabricius, in 1596, first noted its periodic variations. These take a cycle of between 320 and 370 days to complete ; at maxima it will reach magnitude 2 on occasions, but is usually about magnitude 3, less frequently 4, more rarely only 5. At minima it usually descends to magnitude 9, and has reached 9·6. As this star is most of the time below 6th magnitude, its absence from the sky is readily noted.

Super-heated Gases

It is also perceptible for between 80 and 90 days after maxima; like the Cepheids, the decrease is not so rapid as the increase. But the ascending light curve is less steep and much less regular than in those of the Cepheids, thus suggesting spasmodic outbursts ; these produce colossal eruptions, which may amount on occasion at maximum to 10,000 times the star's luminosity at minimum.

The star χ Cygni is another notable example, in which the light has been known to increase

35,000 times, from a minimum of 13·7 to a maximum of magnitude 4·8, in about 8 months. Its light curve shows varying maxima and minima, and with the ascent nearly twice as rapid as the descent, or decline in brilliancy.

Over 1,000 of these long-period variables are known, and it has been found impossible to formulate any theory fully to explain all their variations and to ascribe them to any one cause. Some undoubtedly pulsate. Two giant variables, Betelgeuse and α Herculis, have been measured by interferometer. Thus a good idea is obtained of the immensity of the change that must take place in the star's volume, as well as its brilliance. α Herculis, while at the maxima of its pulsations, will radiate about 620 times more light than our sun; whereas at minima, which occur at intervals of only 120 days, it radiates only about 300 times more

A probable solution in other instances is that clouds of less luminous material envelop these giant gaseous M stars, increase during quiescent minima, and are subsequently rent and temporarily dispersed by the great uprush of super-heated gases from below Then the star appears as a great blaze of light, like o Ceti.

Irregular Variables

One type of the irregular variables class is the U Geminorum. These are faint stars which have periodic outbursts at irregular intervals of a month or two lasting but a few days In U Geminorum two different maxima occur at intervals of between 40 and 150 days, when it will increase from magnitude 13½ to nearly 9 in 3 or 4 days, then diminishing like a Cepheid, and later, after a varying interval, rise to perhaps magnitude 8 8. The stars SS Cygni vary similarly from magnitude 12 to 8·5, and SS Aurigae from 14·7 to 10·5.

Another singular type of irregular variable is R Coronae Borealis. While normally of magnitude 5·5, at irregular intervals its light decreases to 7 or maybe down to magnitude 15; it then remains so for a few months or several years, subject to slight variations.

Faint and Red Stars

There are a number of generally faint and red stars, chiefly of the types Me, N, and S, whose variations are less than 2 magnitudes. With but few exceptions they appear to be suns approaching the end of their luminous radiation Normally they are very faint, of 13 magnitude or below; at irregular and usually long intervals they will temporarily brighten up by 1 or 2 magnitudes, and then revert to their former faintness. Their temperatures are low, about 2,000° Centigrade. The explanation of their variability would appear to be that more or less solid surfaces are forming which are periodically broken up by outbursts of incandescent material from below these less luminous molten or solid surfaces. The star U Hydrae is an example of this type, varying from magnitude 4 5 to 6 1–6·3, and with an Nb spectrum devoid of violet light.

LESSON 29

Novae or New Stars

THE novae or "new stars" are new only in the sense that they blaze up and present the spectacle of a brilliant star where nothing before was perceptible to the naked eye. By means of the higher telescope powers and the more complete methods of stellar photography now available it has been found that a faint star originally existed where the outburst occurred, and that what was observed was not actually a new star but an old one which had become subject to some celestial catastrophe. The brilliance rapidly fades and the star slowly dwindles to a faint telescopic visibility again after sundry oscillations in brightness. Such is the normal life of so-called novae.

The method of nomenclature adopted is the word Nova followed by the name of the constellation in which it appeared and the year. Nova Persei 1901 was discovered by Anderson on February 22 of that year. It was the first to provide visual evidence of what had happened. This star increased over eight magnitudes in 28 hours, finally exceeding Capella in brilliance. So colossal was the outburst that in four days its light had increased 20,000 times. It soon diminished; after 24 hours its brilliance had decreased by one-third, and in about a year it had dwindled to twelfth magnitude.

Stellar Conflagrations

In the meantime the ordeal of the star had been revealed, for a cloud of faint light was subsequently seen to be enveloping Nova Persei; later it was found to be expanding at a great rate. This continued until, after about 8 months, it had attained the enormous apparent distance of about a minute of arc from the star. When the distance of Nova Persei from us—about 111 parsecs—was taken into account, it became obvious that the luminous clouds, if they were travelling, were doing so with the speed of light. Since this was an impossibility, the true solution appeared to be that what was observed was the light of the colossal conflagration on Nova Persei travelling outwards and illuminating clouds of nebulous matter in its

path long after the outburst itself had died down. This discovery was held to prove the truth of one of the supposed causes of these outbursts—that they were due to a faint and relatively small sun rushing into a nebula or cloud of dark matter and consequently blazing up into a terrific incandescence, on the same principle as that which causes a great meteor to blaze on entering the earth's atmosphere—though with this difference, that in the star the conflagration is relatively only superficial, for after passing through the nebula it again settles down to the condition of an apparently faint star, but at a higher temperature and magnitude than it was before. In some cases, as with Nova Persei, the star is later found to be surrounded by a vast nebulous envelope or gaseous shell as the result of the outburst ; this is revealed both visually and spectroscopically.

Terrific Convulsions

Nova Aquilae 1918 was the brightest nova of modern times, exceeding all stars in apparent brilliance except Sirius and Canopus. Its rise from the eleventh magnitude to $-1 \cdot 0$ took only about four days, from June 5 to 9, during which time its luminosity had increased about 3,000 times. Having attained maximum, it immediately began to diminish, and a fortnight later was of only third magnitude, and six months later it had diminished to sixth magnitude.

It was one of the most exhaustively studied of all novae, particularly in its spectroscopic changes. By a fortunate chance it was photographed on June 5 at Heidelberg, when the star was of only 10·5 magnitude, and at the beginning of its conflagration Another fortunate chance provided a photograph of this celestial region on June 7, when Nova Aquilae had attained sixth magnitude ; by the next evening it was of first magnitude and its true character was realized.

Meanwhile many spectrograms had been obtained indicating the terrific convulsions the star was undergoing, far exceeding in magnitude and velocity any other known celestial phenomena. The absorption lines of the spectra, indicated immense radial velocities of approach reaching to over 1,400 miles per second, revealing the explosive force of the gases which expanded in all directions outward from the star. This became *visible* as a vast shell of luminous vapour or nebulosity, and then became a luminous disk, which continued to expand for several years until it attained the immense diameter of 16″. While the light curve was very similar to that of Nova Persei, and showed minor fluctuations as it decreased, there was no evidence that Nova Aquilae had become immersed in a dark nebula (as had happened to Nova Persei), which could be accounted a possible cause of the outburst. The evidence suggests that the luminous nebulosity was due to a colossal explosion of Nova Aquilea itself.

Nova Cygni 1920 was discovered by the astronomer Denning, on August 20, when its magnitude had increased to about 3·5. By August 22 it had reached magnitude 2·8, and on August 24 it attained 1·8. Its total increase of luminosity must have been far greater than that of Nova Persei or Nova Aquilae, because photographs taken before the outburst and registering stars down to 15 magnitude show no trace of the star ; the increase must have been stupendous, and the catastrophe the greatest known. The decrease was most rapid, the nova declining to magnitude 4 in a week and magnitude 9 in a couple of months. It appears to have been originally a small star at a distance of $38\frac{1}{2}$ parsecs, and much nearer than the other novae. Though no shell or disk of expansive gases was observed, yet its spectrum indicated terrific radial velocities, amounting to as much as 1,100 miles a second ; so apparently Nova Cygni 1920 was of the same type as Nova Aquilae 1918.

Mystery of Nova Pictoris

Nova Pictoris 1925, first noted in May of that year, provided a somewhat different spectacle and a unique problem. This star, which was observable only from southern latitudes, blazed up to about 60,000 times its original brilliance.

NOVA PICTORIS. First observed in May 1925, this star suddenly attained to an extraordinary degree of brilliance and then slowly waned, until in January 1928 observers noticed the appearance of a nebulous ring. This continued to expand until in March 1928 two stars were seen where one had been before. It has been suggested that in 1925 Nova Pictoris was split in two as the result of an internal convulsion or of the impact of another star.

Its increase took several days, and it remained bright for a longer period than is usual with novae, being still of third magnitude in the following September and remaining visible to the naked eye for over three years.

A singular feature of this outburst—which was obviously a different convulsion from those already considered—was the appearance of a nebulous ring, not seen until January 1928, which continued to expand. By March 1928 Nova Pictoris had apparently divided into two separating stars. Bearing in mind the distance and date of the convulsion, it would have taken quite three years for the separation to have become perceptible even in powerful telescopes, that is, supposing the stars to have divided with speeds of several hundred miles a second.

The nebulosity had by this time attained a diameter of about 6′ and exhibited condensations similar to those of Nova Persei 1901. In view of the stupendous diameter represented by this nebulous ring, and the presence of two inner rings, it became obvious that what was being witnessed was the progress of the light of three successive outbursts through a vast and otherwise invisible nebula. Whether this stellar catastrophe was caused by the rending asunder of a star by some explosive force within itself, or by its becoming immersed in the dark nebulous matter, it is impossible to say. The conflagration might have been caused by two suns or a sun and a dark world colliding, but this theory is generally discounted because of the immensity of space between independent stars. In Nova Pictoris it would not account for the presence of the vast nebula. It is possible that the two stars of Nova Pictoris were originally there, that one of them was becoming a dark world, and that the whole was rejuvenated by the nebulous immersion.

Nova Herculis

Nova Herculis 1934 was another interesting example, similar in some ways to and yet different from Nova Pictoris. The outburst happened at a distance of some 1,500 light-years and was on the decline when discovered, but in view of the star's original faintness it was estimated that it had increased in luminosity by at least 400,000 times. Its light fluctuated considerably during the first six months of observation. This suggested subsequent outbursts of vast extent—after declining to 13 magnitude, it brightened up again to 7½ magnitude.

A surprising sequel was the discovery, some six months after the outburst, that two stars had apparently come into being. This was closely studied, particularly with the 40-inch refractor at the Yerkes observatory (Chicago University, U.S.A.), and the two stars were found to be separating. Measurements of their rate of motion revealed that they were separating at the uniform rate of about 380 miles a second. At this rate the two stars would have about covered the distance between them, from the time of the outburst. Observation continuing showed that in 1937, three years afterwards, the distance between the stars had increased uniformly from about 2″ to 6″ and was continuing.

Early Novae

Records of novae go back for over 2,000 years. The first was noted in Scorpius in 134 B.C., and another in Ophiuchus in 123 B.C.; one in Centaurus in A.D. 173, the next in Aquila in A.D. 389. All these were of about first magnitude and, as is usual with novae, in or near the Milky Way. Scorpius again had novae in A.D. 827, 1006, and 1203, all about first magnitude. Ophiuchus had another nova in A.D. 1230.

The nova of 1572 was the most brilliant known; it appeared in Cassiopeia, and was called Tycho's star. It was brighter than Venus at her greatest brilliance, and reached −4 magnitude, being visible during the day. After 16 months it became invisible. During 1604 another very bright nova called Kepler's star appeared in Ophiuchus; it reached −2 magnitude. These are now classed as probable *supernovae*—a type of star whose outburst is similar to, but bigger than, those of common novae.

Novae usually appear in constellations of the Milky Way and in the nebulous areas within 10° of the galactic equator, the medium line of the Milky Way. Numbers of the fainter telescopic novae occur in Scorpius and Sagittarius. Aquila Perseus, Cygnus, Ophiuchus, and Gemini follow closely in the occurrence of these outbursts.

LESSON 30

Open and Globular Star Clusters and Star Clouds

STAR clusters are those aggregations in which groups of stars are physically associated, and are quite distinct from artificially grouped constellations. They are divided into *open clusters* and *globular clusters*. The first variety, of which about 200 are known, consists of clusters in which large numbers of stars are apparently massed together in an irregular manner with many outlying members, as in the Pleiades and Hyades clusters, which are two of the few open clusters visible to the naked eye. It is usual for members of the cluster to have

a similar proper motion and to average about the same distance from the earth. So it comes about that in some cases there are numbers of bright stars apparently not close together, or clustered, which nevertheless are found to form a cluster ; the individual members appear far apart on account of their comparative nearness to our planet. Nearly all the stars of Orion and most of those in the Plough area of Ursa Major form two open clusters. Our sun is a member of a cluster with Sirius, Procyon, Alpha Centauri Altair, and lesser luminaries.

The thousands of millions of stars composing the universe are not distributed evenly or at haphazard throughout the heavens, but are arranged in groups—in clustered masses like eddies in a vast swirl of waters. Though apparently massed together, the stars are nevertheless separated from each other by distances usually to be measured in light-years and approximating to the distances of the nearest stars to our sun.

Open Clusters

The Hyades is the nearest of these open clusters, and averages about 40 parsecs distant. In this are calculated to be about 100 stars, 40 of them larger and brighter than our sun. The whole forms a cluster between 30 and 40 light-years in diameter, all travelling in a similar direction, towards the east. This cluster contains approximately a similar number of stars to that contained in the same cubic space of our solar cluster. Some of the stars for instance, Aldebaran lie between us and the Hyades, and many faint ones are beyond it ; stars which are not members of the cluster can usually be distinguished by their different parallax and proper motion.

The Pleiades is the best-known open cluster. It is interesting as a sight test. Seven stars are to be seen by sharp eyes. These were known to the ancients under the names of Alcyone, the brightest, of 3rd magnitude ; Electra, and Atlas, of the 4th ; Merope, Maia, and Taygeta, of the 5th ; and Pleione, of the 6th magnitude. Very good sight could perceive Asterope and also glimpse its companion, Celaeno, under favourable conditions. A field glass will increase the number to between 30 and 40, and a powerful telescope will reveal over 2,000 stars in this field, a large number of which are members of the Pleiades cluster. Its average distance is about 100 parsecs, a singular feature being the radiant nebulosity surrounding the brighter stars, which are of the B class. This nebulous matter apparently fills most of the space between the stars ; it is believed to fluoresce by reason of the intense luminosity of these helium suns.

THE PLEIADES. One of the most familiar objects in the winter sky, the Pleiades cluster consists of more than two thousand stars, although only six or seven are visible to the naked eye. The brighter stars are of the helium type, and many are surrounded by a vast radiant nebulosity.

The greater the distance of these known agglomerations of stars, the more they help astronomers to gain some idea of the structure of the universe. Many of the open clusters are between 2,000 and 3,000 parsecs distant. The density of the stars in the various clusters differs immensely, and is usually much greater towards the centre. In some instances the number of stars is a thousand times greater than in our solar cluster.

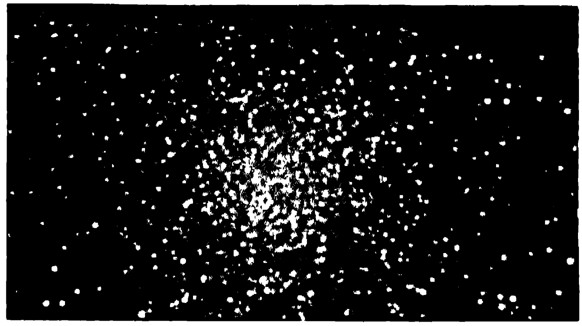
Spectroscopic examination of the members of clusters shows that every type of star is represented, but in some clusters certain types predominate. For instance, in the Hyades and Praesepe the A class predominates in the brighter stars ; in the Pleiades and Orion clusters the B class stars are the most numerous and the brightest.

Star Clouds

Numerous nebulous patches of light in various regions of the heavens are composed of innumerable stars. Two such are in Perseus, and known as H.VI.33.34, and in this double cluster many of the stars are revealed by field glasses. Other impressive areas, most of them much more extensive, require powerful telescopes to resolve them into stars ; they are then found to amount to many millions, and are usually designated *star clouds*.

The nomenclature adopted is that of the following generally accepted catalogues. The first was that of Charles Messier (1730 1817), made in 1784. This contained nomenclature for all the brighter objects then observable, and is still most generally used for those objects, which included nebulae as well as star clusters, the essential differences between the two being then unknown. Altogether 103 items were catalogued, and they are now referred to as, for instance, M.44 for the Praesepe, M.35 for the splendid cluster in Gemini.

Subsequently, Sir John Herschel compiled some lists which were gathered into a general catalogue. The double cluster in Perseus has come to be known as H.VI.33,34. By the year 1887, Dreyer's new general catalogue, containing 7,840 objects, was produced ; in this, the Praesepe M.44 becomes N.G.C.2632. Dreyer's catalogue refers mostly to the fainter objects, chiefly nebulae which had been revealed by the higher powers of the telescope, and a supplement is the index catalogue, which adds about 6,000 more objects, chiefly faint nebulae.



A STARRY MAZE. This photograph is of M.13 in Hercules, a typical globular cluster which is so far removed from us in space that Sirius, the apparently brightest star in the heavens, would be quite invisible to us if it were situated at the same distance. Each one of the stars in the cluster must therefore have an actual luminosity greater than that of Sirius.

Globular Clusters

The globular clusters are totally different from open clusters ; about 70 are known, and they constitute remarkable agglomerations of suns into what would seem to be small island universes apart. The number of stars each cluster contains must average at least 50,000, probably many more, as suns the size of ours would not be perceptible at their great distance. Moreover, toward the centre these clusters appear so condensed that individual stars are indistinguishable.

Every type of star ranging from Class B to Class M is present, the latter being the largest. They contain numerous variable stars, proved by taking photographs at short intervals ; thus both short-period Cepheids and long-period variables are revealed. The presence of Cepheids has proved to be a valuable aid for estimating the distances of these clusters. This has been ascertained by means of the period-luminosity curve, which provides mathematically the absolute magnitude of the particular star. The difference between the absolute and the apparent magnitude gives the distance, by the method already described as applied to the stars. The distance of the clusters being thus obtained, their size is only a matter of calculation, and so it is found that the diameters of these clusters must approximate to at least 30 parsecs. The condensation of stars toward the centre will be very great ; there must be over a thousand stars in some cubic regions of these clusters, where there is but one in a similar cube of space in our part of the universe.

The nearest of all these star clusters is the grand spectacle of ω Centauri. It was so titled because to the eye without telescopic aid it appears as a hazy 4th-magnitude star and its true character was not then known. Now it is seen to be a still vaster cluster than M.13 and about 6,500 parsecs away. The farthest clusters are over 70,000 parsecs distant.

The arrangement of these clusters in space takes the form of an ellipsoidal region some 75,000 parsecs in diameter, centred on the centre of the Milky Way system. The solar system is situated on one side of this vast area, accounting for the fact that the clusters are almost exclusively found in the half of the celestial sphere that is within 90° of the constellation of Sagittarius, which lies in the direction of the centre of our universe.

LESSON 31

Principal Classes of Nebulae

Nebulae are faint ill-defined areas of light usually of small apparent extent and resembling wisps of luminous mist. They present every conceivable form, and are generalised into four classes : (1) irregular nebulae ; (2) planetary nebulae ; (3) dark nebulae ; (4) spiral nebulae. Between 2,000,000 and 3,000,000 such areas are known, most of them through the application of long-exposure photography in conjunction with very high telescopic powers.

Some of these hazy spots of light having been revealed by increases in the powers of the telescope as clusters of stars, the opinion was formed that all were simply star clusters so far away that their light merged into the impression of nebulous light as does that of the Milky Way. This assumption was destroyed by the spectroscope, which distinguishes with certainty between the light sent to us from a massive star and that emitted by a gas. When this instrument was applied to the nebulae, it showed that whereas some were composed of groups of stars, others were

beyond doubt, masses of luminous gas. The so-called nebulae were therefore divided into two groups, the gaseous and non-gaseous.

It was soon noticed that whereas the gaseous variety shone with a bluish light, the other radiated a white light, this being due to the differences in their sources. A few examples of both types are perceptible to the naked eye.

PLANETARY NEBULA. Planetary, ring, or disk nebulae apparently consist of vast luminous atmospheres, surrounding a comparatively faint star. This photo is of the nebula in Lyra, one of the best known of the disk nebulae so far observed.

Irregular Nebulae

Irregular nebulae are essentially gaseous, bluish in tint and occasionally associated with highly incandescent stars of very great temperatures. Such, for example, is the nebula of Orion, which can be seen on any dark and clear night below the " belt " of Orion, and extending for a considerable apparent distance from the multiple star θ Orionis.

Various portions of this nebula are in motion in different directions, amounting to as much as 6 or 7 miles a second, and suggesting a rotary motion which indicates a period of about 300,000 years. Actually this nebula extends as a diffuse nebulosity for about 45° to 30° over an area much larger than the constellation of Orion, and enveloping most of its stars, including the three stars of the " belt."

Other nebulae of this first class visible in the low powers of the telescope are the " dumb-bell " nebula in Vulpecula and the " crab " nebula in Taurus, now believed to be the remnants of a supernova observed by the Chinese in A.D. 1054. The extensive nebulosities surrounding many of the Pleiades are also of the irregular class, and there are numerous areas in Scorpius, Sagittarius, and Cygnus. The " looped " nebula in Dorado is the largest known irregular nebula, with a diameter calculated at 130 light-years.

HORSE'S HEAD IN ORION NEBULA. Some of the vast spaces between the stars are occupied by nebulous matter, which in parts is illuminated by the stars. The intervention of dark non-illuminated nebulous masses is strikingly shown in this photograph of the so-called horse's head region of the great Orion nebula.

Photo, courtesy of Mount Wilson Observatory

The spectra of these irregular nebulae consist of a faint continuous spectrum upon which is superimposed a line emission spectrum ; lines of hydrogen and helium are pronounced, together with two green lines, which were long unidentified but are now attributed to oxygen in a peculiar physical state.

The densities of these nebulae are exceedingly low, estimated to be many billions of times less than the earth's atmosphere—far less than can be attained in an artificial vacuum. For such rarefied matter in space to be incandescent and produce the spectra of hydrogen and helium seems out of the question.

Planetary Nebulae

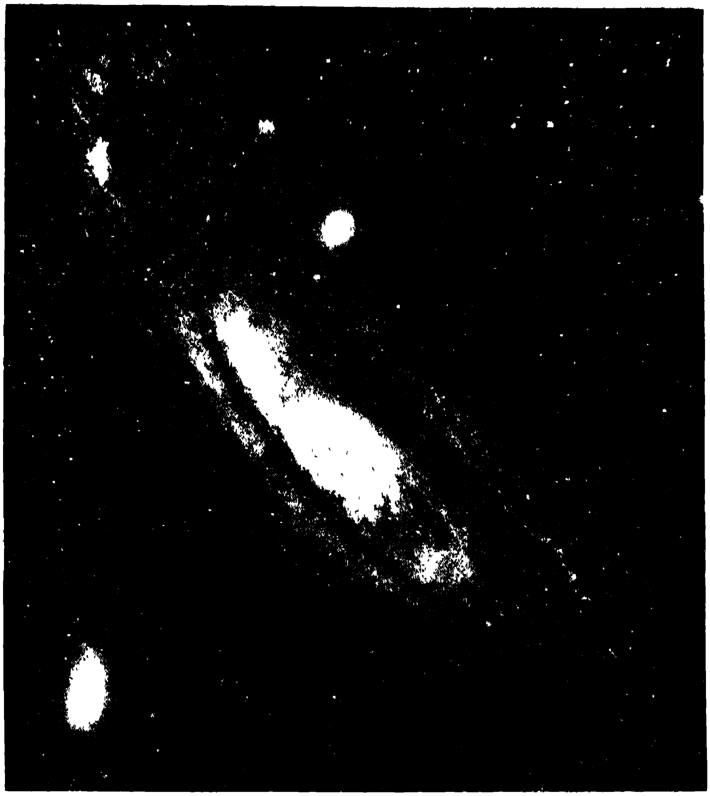
Since these gases in a state of incandescence are most prominent in the stars which are enveloped or associated with these vast areas of diffuse nebulae, it appears that these stars cause the luminosity observed in the nebulae. This circumstance is well displayed in the way in which the Pleiades light up the surrounding nebulous masses. These nebulous masses are in motion and the light has been observed to change with the movement.

In the second class (planetary nebulae) the nebulae are smaller than in the first class. They are also denser, more massive, and almost regular in outline, presenting

under low magnification a disk which looks like that of a planet seen out of focus.

Though a few of these nebulae have a diameter approaching 12′, most of them are much smaller. About 150 are known, and of these the "owl" nebula in Ursa Major—so named from the fancied resemblance of its disk to the face of an owl—known astronomically as N.G.C.3587, is one of the most easily observed. Another is the so-called "ring" nebula in Lyra—N.G.C.6720 in the catalogue nomenclature, which is the same as for star clusters.

This nebula is situated almost midway between β and γ Lyrae, and has an apparent diameter of 1′ 23″ at its widest; it appears as a ring under low magnification, but when photographed with high telescopic powers it is seen to be filled with nebulous detail together with a star in the centre. Most of the disks of planetary nebulae are found, when photographed through powerful telescopes, to exhibit a mass of detail which suggests the rotation of the whole round a central star, nucleus, or condensation. This rotation may take from 5,000 to 15,000 years to complete.



ANDROMEDA NEBULA. The great spiral nebula of Andromeda is another universe similar to our galaxy and composed of some thousands of millions of suns together with numerous masses of nebulae and doubtless myriads of worlds, the whole at a distance of about 680,000 light-years, or 210,000 parsecs.

Photo, courtesy of the Royal Astronomical Society

Other examples are N.G.C.7662 in Andromeda, H.IV.27 in Hydra, and, largest of all, N.G.C.7293 in Aquarius. This, with a diameter of 12′, is at a distance of about 80 light-years and is the nearest known planetary nebula. These nebulae are more numerous in the neighbourhood of the Milky Way, especially in the region of Sagittarius, and are as a rule apparently smaller than those in regions distant from the Milky Way. This is explained as due to the fact that those situated near to the galactic plane (the central line of the Milky Way) are farthest from the earth.

The spectra of this class of nebulae are similar to those of the class O and Wolf-Rayet stars. Some of these so strikingly resemble planetary nebulae that it might be inferred that many of them represent one-time novae, which in distant ages blazed up and have been left in nebulous condition, slowly to die down into stars again.

Dark nebulae were first suspected to exist as many dark patches in the heavens, conspicuous for being destitute of distant stars, in regions—such as certain parts of the Milky Way—where the adjoining areas are dense with stellar luminosity. At one time it was thought that these dark areas were regions destitute of stars; but since Cowper Ranyard drew attention to their singular shape in many of the smaller patches revealed in the early days of celestial photography, it has become clear that they are due to the intervention of opaque cosmic material. Barnard catalogued nearly 200 of these remarkable objects; more have been added by the continued application of photography, particularly in the vicinity of the luminous nebulae, one of the most impressive being the mass of dark material which encroaches upon the bright portions of the Orion nebula illustrated in page 1754. These areas are doubtless dark portions of the nebula itself which obscure the illuminated regions.

Other examples are the "coal sack" in Crux (the Southern Cross), and the dark nebulae in Ophiuchus, Scorpius, Taurus and Cygnus.

Their distances vary from 100 parsecs to the limits of the Milky Way ; they are also associated with many of the open clusters, e.g. the Pleiades and Orion.

The great cleft in Cygnus, perceptible on any dark night in summer and autumn, extends through Aquila to Ophiuchus. It is undoubtedly caused by the intervention of a belt of opaque nebulous matter which obscures part of the Milky Way with its numerous stars beyond, while only those which are between us and the obscuring clouds are perceived. There is probably no difference between bright irregular nebulae and these dark nebulae, except that the former are close enough to bright stars to be illuminated by their light. The material is believed to consist of cosmic particles which may be in size anything from a molecule to a planetoid, and spread through areas measured by hundreds or even thousands of parsecs.

LESSON 32

Spiral Nebulae, and Problems of the Cosmos

SPIRAL nebulae were at one time regarded as masses of gaseous nebulosity which ultimately evolved into suns and solar systems ; but spectroscopic analysis of their light, together with photography applied with greatly increased powers of the telescope, has revealed them to be composed almost entirely of myriads of individual stars, with features which distinguish them from every other class of celestial object. They are, in fact, nebulae only in appearance.

Though more numerous than the true or galactic nebulae, these so-called nebulae are spread over the sky on a totally different plan, their numbers apparently increasing towards the *galactic poles*, particularly the northern, and there being only very few within 20° of the median line of the Milky Way.

Extra-galactic Nebulae

The spectroscope, with the aid of long-exposure photographs, shows the spectra of spiral nebulae to be continuous and crossed by numbers of dark absorption lines—just such spectra as are obtained from the sun and the stars. Thus it has been ascertained that these so-called nebulae are composed of suns more or less similar to our own, and since nebular lines are also present in certain localised areas, gaseous nebulae are also present as in our *galactic system*. So they are galaxies apart from the galaxy of which the solar system is a constituent, and they are often referred to as extra-galactic nebulae.

Photographs taken by long exposure for several hours have revealed the dim patches of misty light to be composed of star clouds, clustered masses of suns, the larger of which are individually perceived in the nearer of the " nebulae." The whole usually appears arranged as a vast spiral, the arms composed of streaming star clouds intermingled with nebulosity and frequently more bluish at the outer than the central regions. In some instances there are belts of dark nebulous matter, generally extending round the outer regions of the spiral, which partially hide the stellar radiance beyond, as in our galaxy. The centre of a typical spiral consists of a massed condensation of stellar radiance in which the individual suns appear clustered and require still higher powers of the telescope to resolve.

The spirals exhibit every variety of form ; variations are increased by perspective. They appear to be somewhat flattened lens-shaped agglomerations of thousands of millions of suns and doubtless numerous worlds, together with star clusters and nebulae proper, such as enter into the composition of our galaxy. In a small proportion the spiral form is less obvious owing to various irregular star clouds and streams of nebulosity disguising the structure ; these are called *irregular spirals*. In others the spiral form is not obvious.

In the larger and nearer of the so-called spiral nebulae both variable stars, particularly Cepheids, and novae are found. The Cepheids have proved to be most important as a means for calculating the distance and immensity of the extra-galactic nebulae. Because it is possible to estimate the absolute magnitude of the Cepheid variables from the period-luminosity curve, their distance can be calculated from the difference between their absolute and apparent magnitudes. These extra-galactic universes are the most distant objects known.

Nebula of Andromeda

One of the nearest is the nebula of Andromeda, at a distance of about 210,000 parsecs, far beyond the extreme limits of our galaxy. This spiral (*see* illus. p. 1755), can be seen with the naked eye almost overhead in the autumn evenings, when it appears as an oval area of faint misty light somewhat greater than the moon's apparent width. Its central regions were resolved into stars for the first time in 1942, and photographs taken more recently by the

200-in. reflector on Mt. Palomar have fully confirmed this structure.

The study of this far-off galaxy has given astronomers some conception of what our own galaxy appears like *from the outside*, as it were. Considerations such as the arrangement of the star clouds of the Milky Way, spectroscopic parallaxes, and Cepheid distances, have combined to give experts fairly accurate grounds for the hypothesis that our galaxy has the form of a spiral and that the solar system is situated somewhere within it, at about 10,000 parsecs from one side and between 20,000 and 50,000 parsecs from the farther and vaguer side.

The centre of the system is estimated to be behind the dense star clouds of Sagittarius and Scorpius at some 10,000 parsecs distant, and the greatest diameter of the whole galactic system is between 40,000 and 60,000 parsecs.

There are two other galactic systems that are known to be nearer than the nebula of Andromeda, but they are to be seen only from more southern latitudes. Visible to the naked eye as large, faintly luminous areas resembling detached portions of the Milky Way, they are commonly called the Magellanic Clouds, but astronomically Nubecula Major and Nubecula Minor. They are far apart, the former chiefly in Dorado, the latter in Toucan. Belonging to the irregular class of spirals, they represent small galaxies adjacent to our own. Nubecula Minor was found to be at a distance of about 32,000 parsecs, and Nubecula Major at a distance of about 34,500.

Expanding Cosmos

The total number of extra-galactic universes represented by these spiral nebulae, as observed by means of the biggest telescope in the world (the 200-inch reflector on Mt. Palomar), approaches 300 millions. The speed at which they are travelling relative to our galaxy is terrific, ranging up to 40,000 miles a second. A circumstance of importance to our conception of the cosmos is the fact that all but a few of the nearest galaxies appear to be receding from our galaxy. From this it is inferred that the cosmos or entire " universe of galaxies " is expanding.

Our galaxy is doubtless travelling at a speed comparable with the foregoing, and in a direction which has no meaning except one *relative* to the others. The time taken also has no meaning except that it is *relative* to the speeds of other objects through space. When mathematically considered as an essential part of the cosmos, space and time are indissolubly linked. The mathematical investigation, begun by Hendrik Lorentz (1853–1928) and elaborated by Minkowski, may be summed up in the latter's words :

> The views of space and time which I have set forth have their foundation in experimental physics . . From henceforth space in itself and time in itself sink into mere shadows, and only a kind of union of the two preserves an independent existence

MEGALLANIC CLOUD, as recorded by the telescope at Harvard observatory. This galactic system belongs to the irregular class of spirals, and it is visible to the naked eye as a large, faintly luminous area.

None of these extra-galactic universes is where it appears to be ; neither are the stellar denizens of our own galaxy ; the *space* separating us from each, and the *time* that light takes in transit across those spaces, vary with the different distances. It has even been conceived that a galaxy which now appears in one region of the heavens may actually be in the opposite region, owing to the lapse of time the light has taken to reach us, 500 million years being taken by the light of the farthest galaxy known.

Einstein's Formulae

Dr. Albert Einstein carried on the work of his predecessors and, in particular, corrected and adapted the famous laws of Newton adequately to explain by mathematical formulae certain observed phenomena in physics, optics, and astronomy. This he presented in his *Special Theory of Relativity* in 1905. His *General Theory of Relativity* (1915) chiefly dealt with optical and electrical phenomena and accelerated motion, even to the extent of predicting certain results. The first was the forward motion of the perihelion of Mercury, which amounts to 40″·1 per century ; Einstein's hypothesis requires it to be 42″·9 per century and is the only adequate explanation.

The second was the bending of light rays when passing near a large gravitational mass

such as our sun ; this was proved to occur by the Greenwich eclipse expedition to Brazil in 1919, when the photographs, taken with great precision, showed that the light from certain stars passing near the sun at the time of total eclipse was bent towards it to the observed extent of 1″·98, whereas Einstein predicted 1″·75. Subsequent work has confirmed the value of about 2″, and the excess over Einstein's prediction remains unexplained.

The third was the displacement of spectral lines so that they shift towards the red end of the spectrum, as the result of the vibrations becoming slower when the light is emitted from the sun or any other massive body ; this was also finally proved to occur in the case of the massive companion to Sirius, though the exact amount of the shift in the case of the sun does not fit Einstein's theory.

Einstein's concept of a cosmic universe of fixed and limited extent has had to give place to one conceived by Dr. de Sitter, in 1917, which presents an expanding cosmic universe. This at present is most in accord with the observed receding galaxies. Other concepts are : warped space in gravitational fields ; the possibility of curved space and a spherical cosmos in which light travels in a curved path and may return upon itself, as does the surface of a sphere ; even gravitation as a force is questioned by the new theories. These are largely subjects of mathematical discussion, in which the names of Sir H. Spencer Jones, Dr. de Sitter, Sir James Jeans, Sir Arthur Eddington, Professor E. A. Milne, and Canon G. Lemaître are in the forefront. Their writings should be referred to for a presentation of the various aspects of the problems. Meanwhile this fact remains beyond question : that there is no known limit to *that which is*, i.e. existence, in either time, space, or space-time ; therefore one must infer its infinity and eternity.

LESSON 33

Observatories, Telescopes, and Astronomers

THE earliest astronomical observations were of necessity made with the unaided eye. Mere patient recording of the planetary motions enabled the Chaldeans to make a surprisingly good representation of the solar system (though with the earth, not the sun, occupying central place) ; and the Greeks could predict eclipses with accuracy. During the Middle Ages in Europe angle-measuring instruments lent precision to naked-eye observations, and the inadequacy of the geocentric (earth as centre) idea became increasingly clear. Yet it was still so useful that the heliocentric (sun as centre) theory of Copernicus (1473–1543) was not regarded as so obviously better that it won immediate acceptance.

For Improving Navigation

Until that time the typical observatory was a private establishment set up by some rich patron of the arts and sciences for a gifted observer, and provided with instruments whose only function was to measure angular distances with the greatest attainable precision. But interest in the philosophical aspects of astronomy soon led to setting up of observatories by the Church The Vatican observatory (*c.* 1585) at Rome is the oldest observatory still in operation Furthermore, as maritime commerce grew, the need for a means of determining a ship's longitude when out of sight of land became pressing. This was so important as to be treated as a national matter, and the royal observatories at Paris (1667) and at Greenwich, London (1676), were founded for the purpose of improving navigation

Although by this time the telescope had been invented (1608), no great motive existed for providing the instruments in these observatories with optical aid, for since lenses would not be generally available on board ship it would have been useless to observe fainter stars than could be seen with the naked eye. To men of science less interested in the utilitarian aspects of astronomy, the telescope afforded a fascinating means of studying celestial objects themselves.

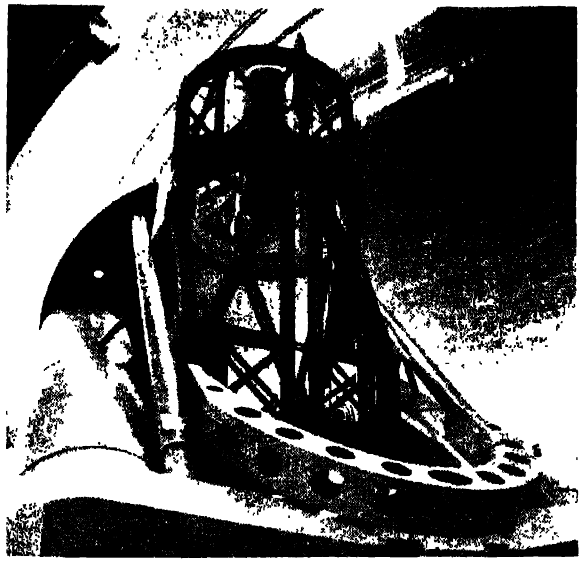
Specialist Observatories

This distinction can be traced in the observatories of the present day. The great national observatories, such as those at Herstmonceux, Sussex (Royal Greenwich Observatory), the Cape of Good Hope, Washington, Paris, Berlin, Poulkova (Leningrad), etc., are virtually alone in making precise observations of the positions of the sun, moon, planets, and stars. These are still needed for navigational purposes as well as for purely scientific work, and the nautical almanacs of the various countries are based on observations made at, and are often actually produced by, the appropriate state observatories.

A similar situation exists in regard to the national time services : the observations of the stars needed to determine the time are now made only at the national observatories, which maintain also the precision clocks needed for distributing the time signals.

University observatories, such as those at Cambridge, Oxford, London, Exeter, Harvard, Copenhagen, etc., though they may originally

have made positional observations, now usually specialise in some branch of astronomy, more particularly astrophysics. Thus the Oxford University observatory is a centre for solar research, while the Harvard College observatory is world-famous for its work on variable stars and on the extra-galactic nebulae, and at Copenhagen special attention is paid to the orbits of comets and minor planets



WORLD'S LARGEST REFLECTING TELESCOPE
(200-inch reflector), at Mt. Palomar, California, U.S.A.
Courtesy of the Mount Wilson and Palomar observatories

Endowed and Private Observatories

A third type of observatory is the direct descendant of the private observatory supported by influential patronage in the past. This is the establishment run by endowment, not from a wealthy individual but from a large philanthropic institution : examples exist at Mt. Palomar (California Institute of Technology), Mt. Wilson (Carnegie Institution of Washington), and Pretoria (Radcliffe Trustees). These observatories maintain the largest telescopes in the world, and make observations on which are based our modern conception of the universe. But they do no positional work, and they take their time and star positions from the national observatories.

Virtually all the world's observatories employing professional astronomers fall into one or other of the three classes just described. There is a fourth kind of observatory : the private observatory in which some interested amateur spends his evenings in scanning the sky. Though most of the observations made in such observatories serve no more purpose than to interest the observer and delight his friends with close-up views of the heavenly bodies, some branches of astronomical observation are almost the exclusive preserve of amateurs. These include visual meteor work, delineation of surface detail on the planets, and some variable star observation.

The happiest collaboration exists between professional and amateur astronomers. The field of astronomy is so wide that it can most efficiently be covered by this collaboration. The time of the big telescopes need not then be taken up in observations that can equally well be made with more modest equipment, and the amateur astronomer does not expend time and effort in attempting observations that are really beyond the reach of his telescope.

All telescopes employ the same optical principle. An image of the distant object is formed by the *objective* lens at its focus. The size of this image depends on the focal length of the objective, but it is never large if the length of the telescope is to be kept within reasonable bounds. (For instance, the image of Mars in even the biggest telescope in the world is never more than a tenth of an inch across.) It is therefore examined closely by means of an *eyepiece*, more or less powerful according to the purpose of the observation.

The *magnification* produced depends partly on the size of the primary image and partly on the power with which it is examined : thus it is defined as the ratio of the focal length of the objective to that of the eyepiece. It may thus be changed at will by the use of different eyepieces ; but because atmospheric tremor sets a practical limit to visibility, it cannot be indefinitely increased by using more and more powerful eyepieces. In a photographic telescope the primary image is received on a photographic plate, and this is examined under a low-power microscope which plays the part of the eyepiece in a visual telescope.

Limitations of a Lens Telescope

The performance of a lens telescope is seriously limited by the fact that the glass of its objective cannot bring to the same focus all the light emitted by the object under examination. It can be improved by making the lens in two components, one of crown glass and the other of flint glass, but even this *achromatic telescope* still shows star images surrounded by coloured haloes. But if the primary image is formed by a concave mirror, the laws of reflection ensure that all the light comes to the same focus whatever its colour.

The first reflecting telescope, made by Sir Isaac Newton with his own hands, is still preserved by the Royal Society in London, and his basic design is followed in all the largest telescopes of to-day. It is, of course, necessary

to have the mirror at the bottom of the telescopic tube and examine the image at the top, or else (by a second reflection) bring it to a more convenient place for the observer. Early mirror telescopes used metal mirrors, which needed expert re-polishing when tarnished. Modern reflectors use glass mirrors with silver or aluminium films deposited on their top surfaces

The largest lens telescopes in the world are the 40-inch refractor at Yerkes Observatory (Chicago), and the 36-inch at Lick Observatory (California). (The size refers to the diameter of the lens.) Pieces of optical glass of this size are difficult to obtain free from imperfections, but mirrors need not be optically perfect, because the light does not pass through the glass. Reflecting telescopes can thus be made of bigger aperture than refractors. The biggest include the 200-inch reflector at Mt. Palomar, the 120-inch at Lick, and the 100-inch at Mt. Wilson (all in California).

It is not essential to receive the focused light by the eye or on a photographic plate. It can be passed through a glass prism to split it into its constituent colours : the resulting *spectrograph* is perhaps the most important single instrument in astronomy after the telescope. By studying the dispersed light of the stars with its help it is possible to determine their chemical composition, their temperature, their speed of motion towards or away from the earth, and even their mass and distance. Any light-sensitive element will serve as receiver, whether at the direct focus or at the focus of the spectrograph.

Radio Telescopes

Increasing use is being made of photoelectric cells, and particularly of *photomultipliers*, in which photocathode and amplifier are contained in the same glass envelope. Image converters such as are used in television are likely to have a great future in astronomy, and it may well be that the formidable engineering problems involved in building bigger and bigger telescopes to the extreme precision needed can be avoided by using more efficiently the light collected by existing instruments.

So far, we have been concerned with optical telescopes which form images by focusing ordinary starlight. In 1932 it was discovered that short radio waves were reaching the earth from outer space, but with the relatively primitive equipment then available little progress was made in their study. The enormous strides in radio technique during the 1939–45 war have now made it possible to construct large radio telescopes. These function by collecting the radio waves by means of a concave " mirror " of wire mesh which concentrates them on to an antenna at the focus. The intensity of the radiation can then be measured by conventional radio techniques.

The biggest radio telescope in the world has a mirror no less than 250 feet in diameter ; it is situated at Jodrell Bank, in Cheshire. It is as yet uncertain what the objects are that can be detected by radio telescopes. They are certainly not ordinary stars, nor indeed do they seem in general to be any celestial object that is prominent optically ; and further elucidation of the new universe of radio stars opened up by radio telescopes must await further observations.

Graduate Courses in Astronomy

The senior posts in observatories are open to university graduates who combine practical aptitude for observing with mathematical ability in analysing their observation. But few British universities offer graduate courses in astronomy (London and Glasgow are exceptions), and most professional astronomers have entered their careers after training in physics or mathematics. Many astronomical posts are open to non-graduates, but it is always desirable to have had a grounding in the physical sciences, if only at school-leaving level.

Increasing use will undoubtedly be made of technicians trained in electronic work ; and computers familiar with calculating machine operation are used in most branches of astronomy. In Great Britain most vacancies occur at the Royal Greenwich Observatory at Herstmonceux, Sussex, where the staff are members of the scientific civil service.

Amateur astronomers are found in the ranks of all trades and professions. Many own their own telescopes, in some instances home-made in their spare time ; but it is possible for those intending serious work to borrow telescopes if they are members of the British Astronomical Association. This is a joint organization of amateur and professional astronomers, which holds regular meetings in London and publishes a monthly *Journal* and an annual *Handbook* which is indispensable to the stargazer.

BOOK LIST

The Sun, the Stars and the Universe, W M Smart (Longmans) ; *Worlds Without End*, Sir H Spencer Jones (English Univ Press) , *General Astronomy*, Sir H Spencer Jones (Arnold) , *The Stars in Their Courses*, *The Mysterious Universe*, *Through Space and Time*, all Sir James Jeans (C.U P.) , *The Expanding Universe*, Sir A. Eddington (C U P) , *The Realm of the Nebulae*, Edwin Hubble (O U.P) , *The Origin of the Earth*, W M. Smart (C.U P.) ; *Telescopes and Accessories*, G Z Dimitroff and J. G. Baker (Churchill) , *Frontiers of Astronomy*, F. Hoyle (Heinemann) , *The Sun and its Influence*, M A. Ellison (Routledge and Kegan Paul) , *Star Atlas*, A. P. Norton (Gall and Inglis).

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16 LESSONS

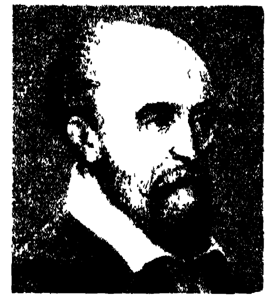
LESSON 1

French—I: "Chanson de Geste" to Malherbe

François Villon

François Rabelais

Montaigne



Pierre de Ronsard

The earliest French literature is ecclesiastical; there are some charming legends of the saints and various didactic poems. Mere fragments survive of the primitive verses, or *cantilènes*, which the Frankish troubadours extemporised to celebrate notable occasions, but from them the *chansons de geste*—songs of heroic deeds developed.

These glorified the prowess of heroic figures; their background was feudal France. They were sung or chanted by wandering jongleurs or troubadours who provided a musical accompaniment. To avoid tedium the narrative was divided into episodes which could be wound up at will by the interpolation of a few concluding lines. These episodes, like those of *The Arabian Nights*, their prose counterpart in the East, were transmitted by word of mouth from one generation to the next, and were supplemented and embellished by successive jongleurs, until finally they were set down in manuscript.

The chanson de geste flourished especially in the 11th and 12th centuries; altogether 95 specimens are still extant. They can be regarded as falling into three main groups: the cycle of Charlemagne, the cycle of Guillaume, or Monglane, protector of Charlemagne's weakly son, and the cycle of Doon de Mayence, a rebellious vassal of Charlemagne. In their original form they amounted to well over 300,000 lines. Metrically they were divided into *laisses* or stanzas of varying length, each held together by a single assonance or vowel rhyme. The lines were usually decasyllabic, but might be octosyllabics or alexandrines (12 syllables).

"Chanson de Roland"

Most famous of these early epics is *La Chanson de Roland* (11th cent.), which belongs to the Charlemagne cycle, or *Geste du Roi*. In some 4,000 lines, divided into five sections, each with numerous episodes, it tells the adventures of Charlemagne's nephew Roland, culminating in his courageous rearguard action against the Saracens at the Pass of Roncevaux in the Pyrenees, and his noble death, fighting alone for "la dulce France." The struggle between France, as champion of Christendom, and her pagan enemies, is idealised, and a rare beauty and nobility are achieved. The Charlemagne cycle also includes the well-known *Huon of Bordeaux*.

Of later growth are the very considerable group of poetic romances. In place of the simple grandeur of the chanson de geste, the *roman courtois*, or courtly romance, offers the complications of knightly adventure and chivalrous love, with a mystical tinge. Whereas the chanson de geste had dealt with old French traditional history ("la matière de France"), the roman courtois ranges farther afield, even into the realms of faery.

Romances

Again there are three main cycles: the Breton cycle, centring upon King Arthur and including the story of Tristram and the legend of the Holy Grail; the cycle of antiquity, in which Greek and Roman heroes play their part, notably Alexander the Great; and the *roman d'aventure*, stories such as the well-known *Guy of Warwick* and *Florys et Blanchefleur*, sometimes of Byzantine origin absorbed during the Crusading period. There is also a group of prose romances, of which the lovely *Aucassin et Nicolette* (13th century) is best known. Most of these romances are by unknown authors, but the name of Chrétien de Troyes should be remembered; he wrote several Arthurian poems of great literary merit, which, translated by the German minnesingers, had a wide influence. The French Arthurian cycle was itself inspired by the Latin chronicles of Geoffrey of Monmouth, which were rendered into French verse by the Jersey poet Wace. Many of these medieval romances found their way into English literature.

Characteristically French are the *fabliaux*, tales of everyday life, usually humorous, in verse. Chaucer and Boccaccio drew largely on these. An offshoot from them was the remarkable *Roman de Renart*, or *History of Reynard the Fox*, which was the nucleus of a cycle of long narrative poems amounting altogether to 100,000 lines. These were extremely popular in the 14th and 15th centuries ; the animals represent the chief figures in church and state, treated allegorically.

" Roman de la Rose "

The allegorical vein is also present in the beautiful *Roman de la Rose*, one of the most important poems in medieval European literature. A love poem, crammed with adventure and wise discourse, it expresses the gaiety, the tenderness, and the mysticism of chivalry at its finest ; and it contains an extraordinary miscellany of scholarly thought and satirical comment on the times. Not only is it the epitome of the Middle Ages ; it is also imbued with the humanism of the Renaissance. Its psychological profundity was something entirely new to the period.

Le Roman de la Rose was the work of two poets. Guillaume de Lorris wrote the early part (*c.* 1225), with its ardent adventures and its gracious revelation of the art of love ; about a century later the scholarly Jean de Meung expanded it from 4,670 lines to 22,818 lines. The influence of this famous poem was marked throughout Europe. Chaucer translated a portion of it. In the 16th century Clément Marot, himself a memorable poet, took the archaic text and rendered it into contemporary French, thus giving it a new lease of life.

Early Lyrics

Lyric poetry was in full flower from the 12th century onwards. It appeared first in the north, where the *trouvères* (wandering minstrels) helped to spread it ; in the south, Provence was its especial home, whence the troubadours carried it to Italy and elsewhere. Love was the theme of many of their songs. In the 14th century, new forms emerged : the *rondel*, now known as the triolet ; the *ballade*, which had three stanzas and an envoi ; the noble *chant royal*, with five stanzas of 11 lines, using the same rhymes throughout, with a refrain ; the *lai*, of 12 or 24 couplets, with two rhymes and a refrain ; and the *virelai*, with stanzas of four to seven lines of varying length.

Much of this early poetry is anonymous, but the names of no fewer than 400 troubadours are known to us, besides many trouvères, the former living in the south, the trouvères in the north, during the 12th and 13th centuries. Chrétien de Troyes, the romance-writer, was among the trouvères, as was Blondel de Nesle, the favourite minstrel of Richard Coeur de Lion. A notable writer of charming lais was the lady known as Marie de France, who lived at the court of Henry II of England

Drama

Dating from the 12th century, the beginnings of drama are in the " mysteries " and " miracle plays," which at first were performed by the clergy in the churches, pictorialising Bible history and the lives of the saints in order to convey their teaching more vividly. Later came the " moralities," which were allegorical or based on secular subjects, often classical ; these were written and performed by companies of lay actors, either in the open air or in a hall. The *sotie*, or social satire, developed from these ; Pierre Gringoire, " Prince des Sots," excelled in this genre The popularity of humour led to the production of downright farce with no purpose except to amuse ; of such, *Maître Patelin* (15th century) is the chief survivor

Chroniclers

Of the historians, the first to write in French prose was Geoffroi de Villehardouin, in the 12th century ; his *Conquête de Constantinople* is a glowing picture of Crusading times. In the following century Joinville's *Life of St. Louis* is the highlight. These bring us to Froissart, whose *Chronicles* have held the admiration of English readers ever since Lord Berners's excellent translation gave them to us (1523 25). This Jean Froissart (1337 *c.* 1400) was a historian with a gift for picturesque writing, who set out to relate the feats of arms which occurred in the wars between France and England throughout the period 1326 1400 ; and a gorgeous, exciting pageant it is. Froissart was also an accomplished poet. As secretary to Queen Philippa, wife of Edward III of England, he had travelled widely.

A more solid historian was Philippe de Commines, who in the reign of Louis XI wrote his *Mémoires*. Gone for ever are the " preux chevaliers " of Froissart's day ; instead we have the modern scholarly technique.

Notable minor poets of the early 15th century were Christine de Pisan, Alain Chartier, and, especially, Charles d'Orléans, the prince who was captured at the Battle of Agincourt and spent a quarter of a century as a prisoner in England, consoling himself with exquisite melancholy verse.

François Villon

It is not until one comes to François Villon (b. 1431) that a truly great poet is found. Little is known of his life, but it was evidently a reckless full-blooded medley of vagabondage, brawling, poverty, and even crime. In 1455 he was involved in a street fight, and accidentally killed a quarrelsome priest ; he had to flee from Paris to escape hanging Afterwards he was

frequently in prison, and was condemned to be hanged for another offence ; the sentence was commuted to banishment for ten years, in 1463, and thenceforward no trace of him remains. His well-known *Ballade des Pendus* and *Ballade de l'Appel* were written while under sentence.

Villon's ideas are simple and familiar, coloured with his own experience and so hauntingly expressed that he touches the deepest springs of the human heart. He loves life and protests vehemently against the ills of circumstance, flinging scorn upon those who harass him, and uttering pity for suffering humanity, for the fading of beauty, and for the troubles of old age ; death is a terror which lurks continually in the background of his thoughts.

He was not a prolific writer : the bulk of his work is to be found in his *Grand Testament*, in which he makes quaint bequests to friends and enemies. Throughout, as in his *Petit Testament*, lovely ballades and rondeaux are scattered, such as the immortal *Ballade des dames du temps jadis*, with its refrain :

> Mais ou sont les neiges d'antan ?
> (But where are the snows of yesteryear?)

This line has become a lament for bygone things.

La Belle Heaulmière is a sombrely magnificent address to a once-famous beauty, now faded and approaching the inescapable extinction that was Villon's conception of death, over which he meditates starkly. Another impressive poem is the *Ballade pour prier Nostre Dame*, written at his mother's request and enshrining the faith of an untaught woman. In the freshness of his work and its passionate intensity, Villon is a precursor of the Renaissance. He marks the end of the Middle Ages.

Age of " New Learning "

The 16th century in France, as elsewhere in western, central, and southern Europe, was dominated by the Renaissance and the Protestant Reformation which accompanied it. It was the age of " New Learning," in which a broad humanism not only sought to recover the great standards of ancient cultures but, stimulated by the revelation of man's potentialities, strove to outdo the past. Humanism has been defined as " the effort of men to think, to feel, to act for themselves, and to abide by the logic of results."

François Rabelais

Now appeared François Rabelais (*c.* 1490–1553), a typical representative of the Renaissance in France. He was a doctor by profession, but he was also a humanist and, furthermore, a man of various and prodigious learning. For a long time he had an unenviable reputation in England because of passages in his works which were deemed to be obscene. But the rollicking *Chronicles of Gargantua and Pantagruel*, a story of giants, is immortal because of its gigantic conception of life and the spirit of laughter that invigorates it. Yet behind the laughter there is always the philosopher, anxious to produce ideas that aid human progress. Our instincts must be marshalled by culture ; nature must be aided by science. That is the essence of Rabelais' teaching. One must not look for order or definite plan in his book, or for details on any one subject. It is the spirit of the whole, a tolerance based on belief in the fundamental goodness of man, that one must accept or reject. By the most enlightened standards Rabelais stands out as a great man. As a writer his style is clear and spontaneous, with an exuberance of vocabulary which is characteristic of his abounding vitality.

Contemporary with him was Marguerite d'Angoulême (1492–1549), sister of Francis I ; she became, by her second marriage, Queen of Navarre. A fluent and versatile writer, she will be remembered for the diverting *Heptaméron*, consisting of some seventy-two stories strung together after the manner of Boccaccio's *Decameron*. In very different style wrote Jean Calvin (1509–64), whose monumental theological work, *L'Institution Chrétienne*, provided a lucid exposition of his own particularly rigid and repressive doctrines.

Montaigne

Of hardly less importance than Rabelais is that other great humanist, Michel Eyquem, (1533–92), Sieur de Montaigne, near Bordeaux, whose *Essais*, read throughout the world, are altogether unique. One can say that here is a man who bases life on reason, who will have no explanation of anything which does not satisfy the reasoning powers of man. Consequently he has been called a sceptic, but this description of him is too superficial ; Montaigne believes in man's noble qualities. The essays deal with almost the whole range of contemporary thought, flitting nonchalantly from idea to idea, from subject to subject, rarely reaching fixed conclusions, but stirring the reader to meditate. Written in flawless style, they open and conclude so naturally that one thinks of them as effortless; actually this is the perfection of art. Florio's translation (1603), which has influenced English writers from Shakespeare to George Bernard Shaw, is the best.

In poetry the next noteworthy figure, after Villon, was Clément Marot (1497–1544). Though not one of the greatest poets, Marot was a consummate artist, and he had that untranslatable quality, " esprit." He excelled in madrigals, in epigrams, and in the graceful witty epistle, and exerted great influence as advance-guard of the " Pléiade." In 1548 the chance meeting of two young poets, Pierre de Ronsard

(1524–85) and Joachim du Bellay (1522–60), led to the foundation of a new group, called " La Pléiade " because at first, like the stars of that constellation, they were seven, the remaining five being Jean Daurat, Jean Antoine de Baïf, Rémy Belleau, Etienne Jodelle, and Thyard.

The Pléiade

In their freshness of thought, their exquisite art, and their haunting music, the Pléiade represent the finest achievement of the French Renaissance. Du Bellay's notable treatise *Défense et Illustration de la Langue française* advocates, in combination with the development of the mother-tongue, a cult of antiquity ; instead of the medieval ballades and chansons, he urged the imitation of classic forms and of the sonnet, newly evolved in Italy.

Ronsard himself is one of the outstanding poets in French literature ; indeed, his lyrics, his elegies, and his sonnets rank with the loveliest ever produced in any country. Most famous are his *Sonnets pour Hélène*. Memorable, too, are many of Du Bellay's poems.

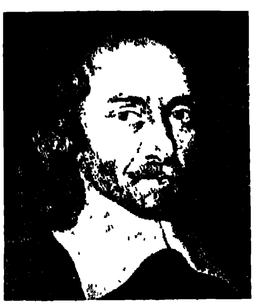
Andrew Lang, in his *Ballads and Lyrics of Old France*, and *Ballades of Blue China*, translated some of the work of these two poets and of others dating back to the time of Villon.

The period concludes with a famous writer— François Malherbe (1555–1628), who laid it down that literature should conform to rules. Archaisms, technical terms, dialect forms, and low expressions were excluded from the poetic vocabulary ; and Malherbe insisted on exact rhymes and measures, and condemned inversions and elliptical forms in syntax. This tended to make verse mechanical ; it clarified the sense, but impaired the spontaneity.

From Malherbe and his period are dated the beginnings of those characteristics for which French literature became so highly esteemed throughout the world. First, scrupulous exactitude in the use of language ; lucidity, precision, economy—these were the aim. Secondly, the appeal to reason ; abstractions, sentimentality and illusions, bad logic, and distractions from the main argument must all be avoided. Thirdly, the greatest French authors have been close observers of human nature, usually in a spirit of tolerance, even of pity.

LESSON 2

French—II : The Golden Age


Pierre Corneille


Molière


Jean Racine


Jean de La Fontaine

THE 17th century, or classical period, can be called the Golden Age of French literature. The growing esteem in which literature was held is shown by two developments which were to have an incalculable influence : first, the "salon," and secondly, the French Academy.

The Salon

The literary " salon " or drawing-room, preluded the Golden Age and has continued in varying fashion up to our own times. It began when the Marchioness de Rambouillet (1588–1665), a rich, cultured woman of Italian birth, opened the doors of her great house in Paris to men of letters. Her salon was their meeting-place for the first half of the century, and attracted the best minds of the age. There they could exchange ideas in a pleasant atmosphere, and many a young author received encouragement. Later the salon deteriorated, becoming the haunt of the affected women whom Molière was to expose in *Les Précieuses Ridicules*, and *Les Femmes Savantes*. *Préciosité*, in its insistence on elegance and refinement, paved the way for Classicism.

Mme. de Rambouillet's example was followed by other leaders of society. Valentin Conrart, a secretary to the king, used to receive once a week a distinguished gathering of men of letters, old and young, who read aloud their new works and discussed them freely. News of these

meetings reached the great Cardinal Richelieu, the "power behind the throne," in the year 1629. That far-seeing man thought, "Why should we not have a sort of central salon, where all the groups can meet? Why not create an official body that will make a duty of conserving our language and encouraging the best that there is in literature?" And so the famous French Academy was founded, and held its first formal sitting in 1635.

The French Academy

The Academy largely succeeded in establishing the form of French literature. From then onwards the French author came under its invisible discipline; as it was an association of the literary élite, not of dry scholastic pedagogues, and as he might one day be honoured by membership, he respected its judgements. The Academy recruited itself by election; there have usually been some forty members. In a robust spirit it undertook the vigilance and encouragement of literature. It has been the background of French literature since the day of its foundation, and its awards are among the most coveted literary distinctions. Under the chairmanship and supervision of a member named Chapelain, a Dictionary of the Academy was prepared. The first edition of this work appeared in 1694; it was revised in succeeding centuries and the present eighth edition is the stand-by of contemporary French authors.

Corneille and Molière

That literature took its classical mould was in a measure due to the labours of Nicolas Boileau (1636–1711), who has been called "the lawgiver of Parnassus." Boileau, like Malherbe, advocated strict regularity and decorousness in poetry, and he urged the wisdom of being guided by the Greek and Latin classics. His own output was, on the whole, undistinguished, and it is as a literary critic that he is important; his *Art Poétique* (1674) was, indeed, a landmark.

The classic period reached its finest flowering in drama. Pierre Corneille (1606–84) was the first great French dramatist; before him the theatre was poor and backward in comparison with that of England. His plays are in verse of unsurpassed eloquence, the measure being rhymed alexandrines. *Le Cid* (1636) is an outstanding event in French drama; it had an immediate success. Corneille studied Spanish drama, and his work, in its nobility of theme and treatment, shows the influence of Calderón; this particular play is based on the *Mocedades del Cid* (Youthful Exploits of the Cid), by Guillén de Castro. *Horace*, *Cinna*, and *Polyeucte* are the best known of Corneille's other tragedies; he wrote eighteen, of which twelve are based on Roman history. He also gave the French stage its best comedy before Molière—*Le Menteur.*

Molière, whose real name was Jean-Baptiste Poquelin (1622–73), came of worthy bourgeois stock. The theatre had an irresistible attraction for him; he changed his name, and became an actor in a travelling company, where he had twelve years of hard apprenticeship. Like Shakespeare, he helped to furbish up old plays and then, happily for mankind, was tempted to try his hand at original composition. He sought out old French tales, old farces, old episodes in the national repertory; some of these were based on the Italian "commedia dell' arte." From them he improvised his plays with the aid of the company, often playing the part of leading man himself.

In this seemingly haphazard fashion Molière evolved some thirty comedies. His masterpieces are: *Les Précieuses Ridicules*, *L'Ecole des Femmes*, *Tartuffe*, *Le Misanthrope*, *L'Avare*, *Le Bourgeois Gentilhomme*, *Les Femmes Savantes*, *Le Malade Imaginaire*, *Le Médecin Malgré Lui*. All his plays, even those with a touch of tragedy, have a very hearty wit and gaiety, and are obviously the work of a man who knew perfectly how to captivate his audience. His high moral purpose is never obtrusive. Goethe pays him this tribute:

> I read some of Molière's comedies every year, just as from time to time I contemplate the engravings of the great Italian masters. For we little men are not able to retain the greatness of such things within us.

Of Molière's immediate successors in comedy, the most important was Jean François Regnard who also thoroughly understood how to amuse his audience.

Jean Racine

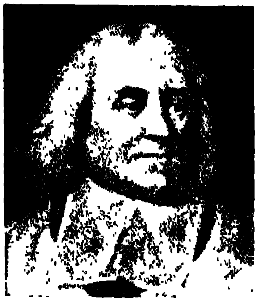
No dramatist differs more from Molière in temperament and in works than Jean Racine (1639–99), who continued the classical traditions of the theatre, resembling Corneille in style and presentation. Racine was an aesthete, a select seminary product, under the influence of the Jesuits of Port-Royal, who were known as Jansenists; Molière was a "bon vivant." Racine based his work on Greek tragedy, mostly Euripides; Molière was essentially French and evolved his own drama. Racine, however, is a masterly dramatist, whose plays are excellent theatre. They move rapidly and logically from beginning to end with the relentlessness of Greek drama. His masterpieces are: *Andromaque*, *Britannicus*, *Bérénice*, *Iphigénie*, *Phèdre*, and his two Biblical plays *Esther* and *Athalie*. The music of his verse is a limpid medium for ideas and can be a gentle caress to the senses.

Fables and Fairy Tales

Lyric poetry is absent from this period; the effect of "L'Art Poétique" had been to curb spontaneity. But we have the genius of Jean de La Fontaine (1621–95), whose truly delightful

René Descartes

Blaise Pascal



Jacques Bossuet

François Fénelon

"Fables" are based on Aesop and other sources. La Fontaine uses an infinite variety of rhythm in his easy-flowing verse, and his rhymes are witty and ingenious.

This same period saw the fairy tale taking literary form. Charles Perrault (1628-1703) published his *Contes du Temps Passé* in 1697, creating the Sleeping Beauty, Cinderella, Little Red Riding Hood, Blue Beard, Puss in Boots, Tom Thumb, and Riquet with the Tuft. Madame d'Aulnoy and other writers followed , and at the end of the following century a vast collection was made, in no less than 40 volumes, entitled *Le Cabinet des Fées*.

Early Novels

The novel was beginning to emerge. Charles Sorel's lively *Vraie Histoire Comique de Francion* (12 vols., 1622-41) was influenced by the picaresque novel which began in Spain in 1554. Paul Scarron's *Roman Comique* (1651-57) is in the same vein. There were also a number of lengthy and far-fetched romances with a pseudo-historical background ; Mlle. Madeleine de Scudéry, one of the "précieuses ridicules," produced some of these, notably *Le Grand Cyrus* (10 vols.) and *Clélie* (8 vols.). About thirty years later came the first novel of psychological interest, Madame de Lafayette's tender romance of *La Princesse de Clèves* (1678). This lady was the friend of Madame de Sévigné (1626-96), in whose thoroughly entertaining Letters, some 1,500 in all, the age of Louis XIV lives before us. Madame de Sévigné was of noble birth, well-educated but no blue-stocking ; she enjoyed with equal zest the gay superficialities of court society and the quiet pleasures of the country.

René Descartes

In more serious vein the Golden Age gave us the great philosopher Descartes and notable moralists, preachers, and prose-writers. René Descartes (1596-1650), by his *Discours de la Méthode*, influenced French thought up to the middle of the 19th century. The Cartesian Method applied mathematics to philosophy, and its exaltation of reason appealed so strongly to the French mentality that authors began to adopt it in addition to the strictly literary principles inculcated by Malherbe and Boileau.

Of the moralists, Blaise Pascal (1623-62) was first to present his thoughts in concentrated form. The *Pensées* of Pascal have an eternal appeal, for they are the attempt of a very fine mind to convince the sceptical or indifferent of the necessity for religion, and they are written in a pellucid style, with an energetic and orderly progression, at times touching high peaks of inspiration and majesty. His *Lettres écrites à un Provincial*, a defence of Jansenism, is a really great dialectic work, achieving its effect by superb irony.

Contemporary with Pascal was the Duke of La Rochefoucauld (1613-80), whose volume of 700 brilliant *Maximes* is as famous as the work of Pascal. La Rochefoucauld sees in self-interest the mainspring of all human conduct and behaviour. To him, if we do a good turn, we never do it disinterestedly ; in final analysis, we do it to give pleasure to ourselves ; but he saves himself from the charge of cynicism by declaring that his *Maximes* are based on his own experience of a corrupt society, and must not be applied to those who have the advantages of Divine Grace.

Famous Prose-writers

The finest preacher of his age was Jacques Bénigne Bossuet (1627–1704), whose sermons attracted so much notice that in 1669 he was appointed tutor to the Dauphin (Louis XIV's son), and afterwards became Bishop of Meaux.

The period closes with three important prose-writers : La Bruyère, Fénelon, and Saint-Simon.

Jean de la Bruyère (1645–96) translated the *Characters* of the Greek Theophrastus, adding his own original work, which at first occupied one third of the book but was enlarged in successive editions. He owed much to La Rochefoucauld's *Maximes*, which determined the form of his earlier jottings ; later he added characters, or satiric portraits, such as were popular at the period. Though not a profound thinker, he is a

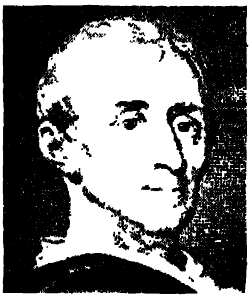
master of style, and the *Caractères*, published in 1688, won instant popularity.

Much more interesting in his ideas, but comparatively dull in style, was François Salignac de la Mothe Fénelon (1651–1715), an outspoken critic of the king and government ; his utopian *Télémaque* is one of the earliest portents of the still distant French Revolution.

Louis, Duke of Saint-Simon (1675–1755), gave posterity in his *Mémoires* a vivid, though not impartial, picture of the times, written in a nervous, brilliantly imaginative style.

LESSON 3

French—III : The Age of Enlightenment ; Romantics and Realists


Baron de Montesquieu


Voltaire


Jean-Jacques Rousseau


Denis Diderot

THE 18th century has been called the Age of Enlightenment. It was an age of free thought and new ideas ; it criticised the existing traditions and authorities with penetrating logic and devastating wit, resolute to destroy in order that the ground might be cleared for reconstruction.

In France there were three outstanding writers whose thought had profound effects upon the political and social history of Europe—indeed, of the world. These three canalised the impetus of the movement which burst on the world as the French Revolution in 1789. They were Montesquieu (1689–1755) ; Voltaire (1694–1778) ; and Rousseau (1712–78).

Montesquieu

Charles-Louis de Secondat, Baron de Montesquieu, was an aristocrat who from his earliest days showed a profound intellectual honesty. He wrote, for the entertainment of himself and others, the delightful *Lettres Persanes*, purporting to be the letters of a cultured Persian gentleman residing in Paris, who wished to convey to his friends at home his ideas of French society and of representative characters. In another work he examined Roman civilization and gave his reasons for its decline, forestalling many of the ideas of Gibbon. But it was his *L'Esprit des Lois* (1748) that most influenced history.

In *L'Esprit des Lois* Montesquieu set forth the results of his life study of the conduct of men and how best they should order their affairs. This book may be called a treatise on political science ; it was also the Bible of liberalism. The author hoped to save the decadent monarchy by pointing to the success of the English monarchy, and the reasons for it. He was too late. Montesquieu put the finishing touch to the ideas of the men who were to lead the Revolution. The theory and practice of "Liberty, Equality, Fraternity" were defined by him

Voltaire

François-Marie Arouet, who took the pen-name of Voltaire, was the greatest literary figure in Europe during most of the 18th century. He is one of the prodigies of all literature, expressing himself in drama, poetry, novels, short stories, literary criticism, history, political and didactic pamphlets, and philosophical treatises.

His works comprise some fifty plays, the best being his tragedies *Mérope* and *Zaïre* ; a vast output of poems, including the epic *Henriade*, the scurrilous *La Pucelle*, the philosophic *Discours sur l'Homme*—which owed something to Pope's *Essay on Man*—and graceful light verse of various kinds ; prose tales, of which the brilliant *Candide* and *Zadig* have become familiar in translations all over the world ; the *Commentaire sur Corneille*, which shows him to be a classicist under the influence of Boileau ; histories, notably *Charles XII*, *Siècle de Louis XIV*, and *Essai sur les Moeurs* (an attack on tyranny), which contain much valuable material and are also very readable ; political treatises, such as the *Lettres anglaises* in which he praised British institutions and ways of thought at the expense

of the French ; discussions of philosophy, such as the *Essai sur la Philosophie de Newton*, and the trenchant *Dictionaire Philosophique* ; and a voluminous correspondence, some 10,000 letters in all, which make fascinating reading, for Voltaire was in close touch with the most interesting personalities throughout Europe, including Frederick the Great and Catherine the Great.

He wrote always in sparkling and impeccable prose, so simple that it can be read with ease by the foreigner who has studied the language for a few months only. Voltaire's earliest efforts made him immediately famous, though one of them, a plea for religious toleration, caused his imprisonment in the Bastille.

Rousseau

In Jean-Jacques Rousseau is seen an altogether different writer. He was born in Geneva, brought up in Switzerland, and for a period during his youth was converted to Catholicism. For many years Rousseau did humble work in order to live ; much of his life was sheer vagabondage, and he did not move in cultured circles until well advanced in years. *Le Rétablissement des Sciences et des Arts*, an indictment of civilization, was crowned by the Academy of Dijon. *Emile* suggested a system of education based on a return to nature rather than on books. *La Nouvelle Heloise* is a novel advocating the reform of marriage.

In 1762 appeared Rousseau's *Contrat Social*, a remarkable book that is responsible for much European thought and contained the germs of the American and French republics. It propounds the argument that " the voice of the people is the voice of God " ; this, with its insistence on equality and the sovereignty of the people, is the central idea of Rousseau's system. As Voltaire had been the apostle of toleration and liberty, so Rousseau was the apostle of equality and fraternity.

As a writer Rousseau is somewhat uneven ; he is often loose in his construction and has not always that clarity which is regarded as an essential of the good French writer. But in one respect he surpasses all his contemporaries—eloquence. It was always far more moving to hear a reading from Rousseau than from any of his contemporaries. In his *Confessions*, a strange, frank autobiography which is now his most widely read book, he is seen as the forefather of the European Romantic movement.

A disciple of Rousseau, Saint-Pierre (1737-1814) wrote the lovely idyll, *Paul et Virginie*.

Diderot and the Encyclopédie

The fame of Denis Diderot (1713–84) has been eclipsed by the greater glory of Voltaire, but their contemporaries regarded Diderot as the profound thinker, the true " philosophe," and many critics have agreed with that verdict. Diderot's output was as immense as Voltaire's, and his range of interests was even wider ; he kept up a constant flow of new ideas, expressed in lucid and stimulating style. Nevertheless he produced no masterpiece. He is remembered chiefly for that tremendous undertaking, the *Encyclopédie* (1750–77), which ran to 34 volumes, of which Diderot was the principal editor.

The *Encyclopédie* was originally intended to be a translation of Chambers's Encyclopedia (1727), but it was soon realized that such a production might have an incalculable effect in moulding popular thought, and the project was therefore modified so as not merely to summarise all existing knowledge but also to destroy such conceptions as could not be justified by reason. Among its contributors were Montesquieu, Voltaire, Rousseau, Diderot himself, the distinguished philosopher and mathematician d'Alembert (1717–83), and Marmontel (1723–99), a novelist, dramatist, and historian.

Another monumental work was produced single-handed by the Comte de Buffon (1707–88), a great naturalist, whose *Histoire Naturelle* (1749–89) ran to 36 volumes.

Drama and Novels

In drama there are the witty sentimental comedies of Marivaux (1688–1763), of which the most popular are *Le Jeu de l'Amour et du Hasard*, *Le Legs*, and *L'Epreuve*. Beaumarchais (1732–99) was author of the delightful *Barbier de Séville* and *Mariage de Figaro*. Le Sage, better known as a novelist, wrote an excellent comedy, *Turcaret*. Marivaux was also a novelist, excelling in psychological interest ; his *Vie de Marianne* and *Le Paysan Parvenu* deal with middle-class life in Paris. More important is Alain René Le Sage (1668–1747), whose *Diable Boiteux* and *Gil Blas* are gaily picaresque in the Spanish manner. The first novel of passion was the world-famous *Manon Lescaut*, by the Abbé Prévost (1697–1763).

There was little poetry in this age of reason, but a revival of interest in Greek, due to archaeological discoveries, prepared the way for André Chénier (1762–94), a genius who has been compared with Keats. Chénier re-created the beauty of Greek antiquity ; he also wrote impassioned satires against the Terrorists and was guillotined by them.

Early Romantics

The first half of the 19th century saw throughout Europe the Romantic revival. By " Romantic " is meant the personal and subjective, deriving from feeling and observation rather than from any rules, and finding expression in a preference for picturesqueness and grandeur, passion, natural beauty, and spontaneity, rather than in the accurate, formal, and well-proportioned. In the work of the Romantic writer form

is subordinated to matter ; the whole is more important than the parts.

Mme. de Staël (1766–1817) and François René, Vicomte de Chateaubriand (1768–1848), were heralds of the Romantic movement in France, of which Rousseau had given the first hints. Mme. de Staël's *De l'Allemagne* was an interpretation of the literature and national characteristics of Germany.

Chateaubriand, in a series of romances, *Atala*, *René*, *Les Natchez*, found poetry in the human heart, with its capacity for love and for renunciation. There is an undercurrent of religious fervour in his work. The range of his ideas is not great, but he showed himself to be possessed of wonderful descriptive powers and a romantic melancholy. His greatest work, *Le Génie du Christianisme*, written after his conversion to Roman Catholicism, had a profound influence.

Romantic Poetry

Greatest of the Romantic poets were Alphonse de Lamartine (1790–1869), Alfred, Comte de Vigny (1797–1863), the prolific Victor Hugo (1802–85), and Alfred de Musset (1810–57). Lamartine's *Méditations Poétiques* (1820) had a sensational success ; these incomparable lyrics revealed the beauty that lies in everyday scenes, as in *Le Lac*, *Le Vallon*, and *L'Automne*. Lamartine had the rare gift of invoking the poetic mood. He published several collections of verse, together with the majestic epics *Jocelyn* and *La Chute d'un Ange*, and also wrote autobiographical novels and historical works.

De Vigny is a poet who stands apart, deeply pessimistic ; he is oppressed by the miseries of mankind, the spiritual isolation of genius, the unresponsiveness of nature, and the imminence of death, which to him means oblivion. He expressed his ideas symbolically in such masterpieces as *Moïse*, *La Mort du Loup*, *Le Mont des Oliviers*, and *La Bouteille au Mer*. The whole of his poetry is contained in *Poèmes anciens et modernes* (1826) and the posthumous *Les Destinées*.

Alike in poetry, drama, and prose, the masterly works of Victor Hugo dominate half the century. In him a great imagination was wedded to a vast energy and industry. He wrote with extraordinary facility and virtuosity on subjects which appeal to the average man ; the amount of his output is amazing, and its artistry is unfailing. The early *Odes* (1822), *Nouvelles Odes* (1824), and *Odes et Ballades* (1826) show characteristics which were to remain with Hugo throughout : the serious conception of his own calling as a poet, the intensely personal revelation of his feelings and ideas, the love of children, the hero-worship of Napoleon. *Les Orientales* (1829) glowingly depicts the romance of the East, developing, in such poems as *Les Djinns*, his superb rhythmical powers. Other volumes of lyrical verse were *Les Feuilles d'Automne*, *Les Chants du Crépuscule*, *Les Voix Intérieures*, *Les Rayons et les Ombres*, *Les Châtiments* (a furious satirical attack on Louis Napoleon), and, most magnificent of all, *Les Contemplations* (1856). *La Légende des Siècles* is a sequence of visions illustrating the march of humanity through the ages ; its most impressive scenes are *Booz Endormi*, *L'Aigle du Casque*, *Le Satyre*, *La Rose de l'Infante*, and *Les Pauvres Gens*. Later collections were *Chansons des Rues et des Bois*, *L'Art d'être Grandpère*, *Les Quatre Vents de l'Esprit*, and *Toute la Lyre*.

The poetry of Alfred de Musset consists of only two volumes, his *Premières Poésies* and *Poésies Nouvelles*. The first was written under the influence of Byron ; the second followed his unhappy love affair with George Sand, of which he gives a deeply introspective study in the four "Nuits" (*Nuit de Mai*, *Nuit de Décembre*, *Nuit d'Août*, *Nuit d'Octobre*). De Musset's range is limited, but he is passionately sincere and capable of very beautiful and musical verse.

An interesting minor poet was Pierre Jean de Béranger (1780–1857), whose volumes of *Chansons*, satirical verse for the man in the street, were extremely popular. He has been called the French Burns.

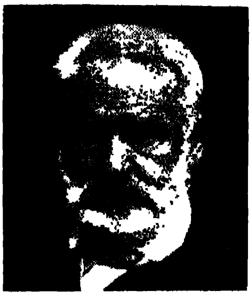
Drama, during the early part of the 19th century, was mainly historical, under the influence of foreign playwrights such as Schiller, or melodramatic. The Romantic revival swept away

Mme. de Staël

Chateaubriand

Lamartine

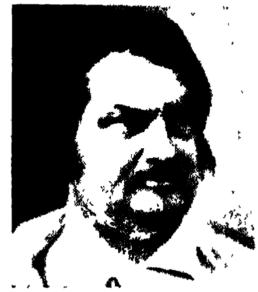
Comte de Vigny



Victor Hugo

Alexandre Dumas

George Sand



Honoré de Balzac

the lingering conventions of classicism. Victor Hugo's preface to his play *Cromwell* sets forth his ideas. Tragedy and comedy should, he argued, be mingled as they are in real life, the unities should be disregarded as cramping, and local colour should be lavishly introduced. These were not new ideas, but Hugo's concise statement came as a landmark (1827).

Cromwell, however, was not intended for the stage ; it has no fewer than 75 scenes and a host of characters. Hugo's later plays—*Hernani*, *Marion Delorme*, *Le Roi s'amuse*, *Ruy Blas*, *Les Burgraves*—contain much beautiful poetry, and the prose *Lucrèce Borgia*, *Marie Tudor*, and *Angelo* are undeniably exciting, but they are unreal. Hugo lacked the power of characterisation ; he simply manipulated the puppet of melodrama.

In this genre the first drama to be performed was *Henri III et son Cour*, by Alexandre Dumas, which, though lacking in literary qualities, made a good lively stage-play and was followed by others. De Vigny, in *Chatterton*, gave a fascinating psychological study of disappointed genius ; De Musset excelled in delightful love-comedies, such as *On ne badine pas avec l'amour*, *Il faut qu'une porte soit ouverte ou fermée*, and *Il ne faut jurer de rien*.

Romantic Novels

The novel was now developing rapidly in France, and it should be noted that the influence of Sir Walter Scott was paramount in the historical novel. It is as a novelist that Victor Hugo is most widely read. Outstanding among his works in fiction are *Notre Dame de Paris* (1831), a colourful representation of the times of Louis XI, and *Les Misérables* (1862), a tremendous panorama of life's tragi-comedy. Later came *Les Travailleurs de la Mer* (1866) and *Quatre-Vingt-Treize* (1874), which are also among the finest French novels.

Alexandre Dumas (1802–70) wrote romantic adventure stories with a historical background ; *Les Trois Mousquetairs* and *Le Comte de Monte Cristo* may be cited as typical examples from a vast output.

The first psychological novels—*Le Rouge et le Noir* (1831), and *La Chartreuse de Parme* (1839)—were written by Henri Beyle (1783–1842), commonly known as Stendhal. This type was derived from the sentimental romance, which originated with the medieval " roman courtois," but Stendhal's delicate analysis is wholly and entirely modern.

George Sand (1804–76), whose real name was Lucile-Aurore Dupin, at first wrote sentimental love-stories, the unhappiness of her own marriage finding expression in revolt against the tyranny of man. Later she produced humanitarian novels, but she was happiest in her idylls of country life, *La Mare au Diable*, *La Petite Fadette*, *François le Champi*, and *Les Maîtres Sonneurs*. She was especially popular in Russia, where Dostoyevsky and Turgenev were among those influenced by her.

Honoré de Balzac

The greatest novelist of the period is Honoré de Balzac (1799–1850), whose *Comédie Humaine* was based on the grandiose scheme of exhibiting every aspect and activity of human life. An exceptionally prolific writer, Balzac reproduced contemporary society with photographic accuracy of detail, in a style which is undistinguished but realistic. His plots are weak and his psychology is unconvincing, but he excels in vivid portraiture ; Eugénie Grandet's miserly old father, and, at the other extreme, the over-indulgent Père Goriot, are striking examples. Of his many other novels, the best known are *Les Chouans*, *La Peau de Chagrin*, *César Birotteau*, *Le Cousin Pons*, *La Cousine Bette*, and *Le Médecin de Campagne*. Balzac also wrote superb short stories.

Gautier, Flambert, and Maupassant

Théophile Gautier (1811–72) is tremendously important ; he expounded the doctrine of " art for art's sake," which was accepted by most writers of the period, notably by Flaubert. Pre-eminently a poet, Gautier was the author of two notable novels, *Mlle. de Maupin* and *Le Capitaine Fracasse* He also wrote excellent short stories,

usually with an interest in the supernatural, as did Charles Nodier, Gérard de Nerval, and Prosper Merimée (1803–70). The work of Merimée, notably *Carmen*, is very vivid.

In the second half of the 19th century Gustave Flaubert (1821–80) is the outstanding novelist. *Madame Bovary*, his first and most famous masterpiece, is the realistic story of a sentimental woman married to a kind but dull husband. After a succession of love affairs she is faced with discovery and ruin, and poisons herself, dying hideously. From this sordid theme Flaubert's second masterpiece, *Salammbo*, is altogether remote, its setting being Carthage after the First Punic War. So scrupulous in detail was the author of this colourful barbaric tale that he not only read every available authority but visited the region. Flaubert's power is revealed, too, in *Un Coeur Simple*, the most moving of his *Trois Contes*.

Flaubert's most important disciple was Guy de Maupassant (1850–93), who wrote numerous contes, some 300 in all, achieving success with his first, *Boule de Suif*. He also produced several novels, sombre in theme, notably *Une Vie* and *Bel Ami*.

Edmond de Goncourt (1822–96) and his brother Jules (1830–70) wrote a series of impressionistic novels on morbid subjects in a nervous, over-refined style. Their Journal, with its stories of celebrities, is to-day regarded as their most interesting work.

Emile Zola

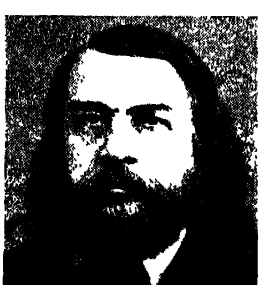
It was Emile Zola (1840–1902) who evolved the theory of naturalism, which he discusses in *Le Roman Expérimental*. His novels have a sociological purpose. The general effect is depressing, since, like the Goncourts, he was often preoccupied with pathological cases. The powerful *Thérèse Raquin* owes much to *Germinie Lacerteux*, the Goncourts' story of a servant's life. In 1871 Zola began his great family-cycle, *Les Rougon-Macquart : Histoire naturelle et sociale d'une famille sous le Second Empire*. The scheme was no doubt suggested by Balzac's *Comédie Humaine*. Zola intended to show various members of the family in their different settings, tracing the influence of heredity and environment and illustrating French civilization during this period. His family, however, are degenerates, and the picture therefore a gloomy one. There are altogether 20 volumes (1871–93), of which the finest are *L'Assommoir*, a shattering exposure of the evils of drink in working-class life ; *Germinal*, dealing with miners and the implications of a strike ; *La Bête Humaine*, in which the chief figure is a railwayman ; and *Le Débâcle*, describing the early part of the Franco-Prussian War. Afterwards Zola wrote the anti-clerical triology, *Les Trois Villes* (Lourdes, Rome, and Paris), and he had produced three parts of another sequence, *Les Quatres Evangiles*, when he died. He wrote masterly short stories.

The naturalistic novels of Ferdinand Fabre (1830–98) deserve mention. His themes are chosen from clerical life ; the most sympathetic is *Mon Oncle Célestin*.

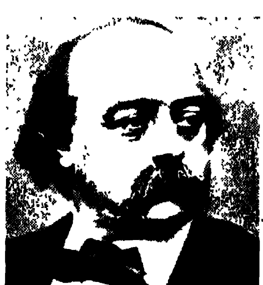
Alphonse Daudet

Last of the important 19th-century novelists is Alphonse Daudet (1840–97), whose most delightful work is in *Le Petit Chose*—a largely autobiographical study of childhood and adolescence, showing the influence of Dickens—and two collections of short stories and sketches, *Lettres de Mon Moulin*, and *Contes du Lundi*. The humorous *Tartarin de Tarascon* and its sequels were most popular, and *Fromont jeune et Risler aîné* and the pathetic *Jack*, influenced by Thackeray and Dickens respectively, must be remembered. *Sapho*, a novel of passion, attracted attention and has been translated.

The century produced fine historians. In the early period François Guizot (1787–1874) is pre-eminent. A great statesman, he found time to write valuable histories, of which the *Histoire de la Civilisation en Europe* and *Histoire de la Civilisation en France* are famous. He was the first philosophical historian, and set an example for the brilliant François Mignet (1796–1884), author of a *Histoire de la Révolution française*, and Adolphe Thiers (1797–1877), who wrote a

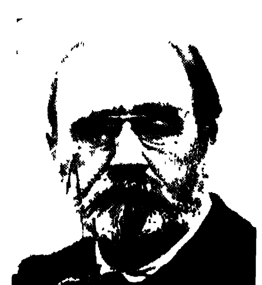


Théophile Gautier



Gustave Flaubert

Guy de Maupassant



Emile Zola


Alphonse Daudet


Ernest Renan


Hippolyte Taine


Sainte-Beuve

much longer work under the same title. Alexis de Tocqueville (1805–59) did excellent work in the same field. More romantic in his love of picturesque detail was Augustin Thierry (1795–1856). The greatest of all was Jules Michelet (1798–1874), whose monumental *Histoire de France* runs to 27 volumes.

In the later period are three great prose writers, Ernest Renan (1823–92), Hippolyte Taine (1828–93), and Charles Augustin de Sainte-Beuve (1804–69). Renan is best known for his *Vie de Jésus*, which raised a storm ; it treated Christ as a human person of historical importance, refusing to accept the supernatural but retaining the moral values of His life and teaching. This was merely the first volume of a great work, *Les Origines du Christianisme*, to which he afterwards linked his *Histoire du peuple d'Israel*. Renan's *Souvenirs* are delightful.

Taine's chief historical work is *Origines de la France contemporaine*. He is best known as a literary critic. Besides several volumes of essays and travel, he wrote a five-volume history of English literature and an important philosophical study, *Thoérie de l'Intelligence*.

Sainte-Beuve is supreme in literary criticism , he covered practically the whole field. For twenty years he wrote newspaper articles embodying a vast amount of research. They appeared on Mondays, and were republished as the fascinating *Causeries du Lundi* (15 vols.) and *Nouveaux Lundis* (13 vols.). Another series was collected in various volumes of *Portraits*.

The diplomat Jean Jusserand (1855–1932) wrote extensively, and his *Histoire litéraire du peuple anglais* is a masterly treatise. Towards the end of the century Rémy de Gourmont (1858–1915) set out to explain Symbolism.

In poetry, the Romantics were followed by the Parnassian school, so called because they came into public notice through the publication of an anthology, *Le Parnasse contemporain*, in 1866. They were influenced by Théophile Gautier, who had been trained as an artist ; shapeliness, colour, and music are the characteristics of his verse, which is at its best in *Emaux et Camées*. His chief disciple was Théodore de Banville (1823–91), a master of rhythm.

Of the Parnassians, Leconte de Lisle (1820–94) and José-Marie de Hérédia (1842–1905) were true poets, as well as superb artists. In the same group, but not in the same rank as poets, were René Sully-Prudhomme (1839–1907), much admired for his philosophic work, and François Coppée (1842–1908), who excelled in everyday scenes of Parisian life and also in poetic drama.

At this period drama was realistic and mediocre. Eugène Scribe (1791–1861) turned out some 400 plays, which were sufficiently well constructed and suited the popular taste. Alexandre Dumas the younger (1824–95) produced a stage masterpiece, *La Dame aux Camélias*, which his many other plays never equalled. Emile Augier (1826–89) wrote bourgeois plays, of which *Le Gendre de M. Poirier* is outstanding. Victorien Sardou (1831–1908) achieved popularity in various forms of drama, and Henri Becque (1837–99) presented squalid scenes in which the realism was a challenge to contemporary artificiality.

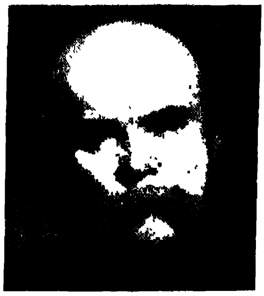
LESSON 4

French—IV : Symbolism and the Moderns

The Symbolists believed that art should be suggestive rather than explicit. Their most important predecessor was Charles Baudelaire (1821–67), whose famous *Fleurs du Mal* appeared in 1857. This is a study of decadence, containing passages of haunting beauty. Less well known are Baudelaire's exquisite *Petits Poèmes en Prose*, which also had a considerable influence.

Paul Verlaine (1844–96) and Stéphane Mallarmé (1842–98) were the leaders of the Symbolist school. Verlaine is surely the most

Charles Baudelaire



Paul Verlaine

Maurice Maeterlinck

Henri Bergson

melodious of French poets, the most intimate. Such poems as *Les sanglots longs des violons*, *Il pleure dans mon coeur*, and *Lune blanche* are of the fabric of immortality, and the volume *Sagesse* contains some of the noblest religious verse ever written. Like Villon, Verlaine led a squalid life, but his glory is undimmed.

Mallarmé lacked this lyric gift ; he was an intellectual, self-consciously applying his theories. He uses words not in their literal sense but as evocative symbols, often disregarding syntax. *L'Après-midi d'un Faune*, his finest poem, inspired the musical composition of the same name by Debussy.

Symbolist Poets

A most interesting figure is Arthur Rimbaud (1854–91), who wrote all his poetry before the age of 19, and then quarrelled with his friend Verlaine and embarked on an adventurous life, eventually becoming an influential trader in Abyssinia. Rimbaud's masterpieces are *Le Bal des Pendus*, *Bateau ivre*, and the prose poems, *Les Illuminations*. *Une Saison en Enfer* records his spiritual development. Rimbaud is still one of the most modern of poets, and his influence has been very great. He is a poet of the depths and shadows of the soul, and there is in much of his work the primitive savagery of the jungle. It is highly disconcerting poetry.

Of the many other Symbolist poets Albert Samain (1858–1900) and Henri de Régnier (1864–1936) are most important. Samain wrote little, but exquisitely. De Régnier was prolific and uniformly excellent in verse and prose ; he was a master of *vers libre*.

Charles Péguy (1873–1914), founder of the influential review *Cahiers de la Quinzaine*, wrote three mystic tributes to Joan of Arc, in the rhythmic prose of *Les Illuminations*, and also wrote verse in regular alexandrines. Francis Jammes (1868–1938) and Paul Fort (b. 1872) handled metre in an original way and expressed a love of nature and religion.

Emile Verhaeren (1855–1916) belongs to the modern movement rather than to Symbolism. A Belgian, he found inspiration in the industrial life of Flanders and the neighbouring French region ; he was also a mystic.

In drama Count Villiers de l'Isle Adam (1840–89) preceded the Belgian Count Maurice Maeterlinck (1862–1949), whose plays, with their brooding sense of mystery, have become world-famous. Maeterlinck's masterpieces are *Pelléas et Mélisande* (made into an opera by Debussy) and *L'Oiseau Bleu*, a fairy play. He also wrote one-act plays, essays, and studies from nature, such as *La Vie des Abeilles*. Another Symbolist, Paul Claudel (b. 1868), won fame as a poet, and wrote the play *L'Annonce Faite à Marie*.

Linked with Symbolism is the philosopher Henri Bergson (1859–1941), whose brilliant exposition of the part played by intuition and by the subconscious, though it came when the Symbolist movement was already in existence, could not fail to reinforce it. Bergson saw life as a continuous stream of energy to which every individual could contribute ; his was a stimulating philosophy. It is set forth in such volumes as *L'Evolution Créatrice*, *L'Energie Spirituelle*, and *Durée et Simultanéité*.

Symbolistic novels are rare : De Régnier wrote several, as did Maurice Barrès (1862–1923) before writing his regional novels. Georges Rodenbach (1855–98), a Belgian poet, wrote the symbolistic novel *par excellence* in *Bruges-la-Morte*.

Great Modern Novelists

Towards the end of the century the greatest novelists were Paul Bourget (1852–1935), Anatole France (1844–1924), and Pierre Loti (1850–1923).

Bourget, a scientist, produced many studies of contemporary morality, applying a keen psychological analysis. *Cruelle Enigme*, *Un Crime d'Amour*, *André Cornélis*, *Le Disciple*, *Un Saint*, *La Terre promise*, *Outre-mer*, *Un Idylle tragique*, *Némésis*, *Agnès Delas*, are characteristic of his very large output, which included short stories.

The greatest of modern French prose-writers, Anatole France (1844–1924), whose real name was Jacques Anatole Thibault, used

the novel as a vehicle for his philosophical ideas, which he presented with consummate skill. His prodigious learning never over-weighted his books, but, handled ironically, was an added charm. He wrote with verve and grace, and often with a robust humour. Best known of his novels are the delightful *Crime de Sylvestre Bonnard*, the Rabelaisian *Rotisserie de la Reine Pédauque*, the satirical *Ile des Pingouins*, the colourful *Thaïs*, the vivid *Lys Rouge*, and the powerful *Crainquebille*. His *Histoire contemporaine* is a sequence of four novels depicting the society of the day ; *Les Dieux ont Soif* and *La Révolte des Anges* developed his political ideas. *L'Etui de Nacre* is a volume of masterly short stories.

Pierre Loti (1850 1923) was a naval officer whose real name was Julien Viaud. His novels are wonderful word-paintings, often with exotic settings, in which the sea plays an important part. *Mon Frère Yves* and *Pêcheur d'Islande* are stories of Brittany and seafaring folk, and *Ramuntcho* deals with the Basque Country ; these are his finest.

Modern Poetry and Drama

A curious phenomenon in poetry was the rise of "Dadaism," the cult of the subconscious, in 1916. The Rumanian Tzara, writing in French, was, with Philippe Soupault, responsible for this new movement, which may, however, be linked with Rimbaud and his very gifted disciple, Guillaume Apollinaire.

Of more permanent interest is Paul Valéry, (1871-1945), who wrote in the traditional manner, achieving perfection of form. His best work is in *Le Cimetière Marin*. André Breton (b. 1896) is a surrealist writer and poet. His great work is *Position Politique du Surrealisme* (1935). Jean Giraudoux (b. 1882), Paul Morand (b. 1888), Jean Cocteau (b. 1892), and François Mauriac (b. 1885) were Dadaist poets who turned to the writing of novels and plays.

In drama, at the end of the century, the problem play had a great vogue in the hands of such writers as Paul Hervieu and Eugène Brieux. Poetic drama had been revived by Bornier and Coppée. In this genre Edmond Rostand (1868–1918) excelled ; *Cyrano de Bergerac* became world-famous. Bernstein has had success in emotional drama, and among the social satirists are Lavedan, Lemaitre, Donnay, Bataille, Courteline, Tristan Bernard, and Sacha Guitry. The famous novelists Mauriac, Rolland, and Romains have essayed drama ; Romains' *Knock* won fame. Original work has been done by Cocteau, Giraudoux, Obey, Maurice Rostand, and others. Outstanding is Jean-Jacques Bernard (b. 1888), whose fine plays show deep psychological insight.

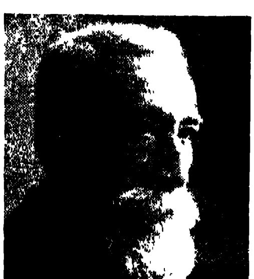
Proust and Others

Most original of modern writers was Marcel Proust (1871–1922). *A la Recherche du Temps Perdu* (7 vols.) is a synthesis of his own life and social background, written in a curious style. It has been translated under the titles *Swann's Way*, *Within a Budding Grove*, *The Guermantes Way*, *Cities of the Plain*, *The Captive*, *The Sweet Cheat Gone*, and *Time Regained*.

André Gide (1869–1951) had considerable influence ; he was influenced by the Russian novelists and by Nietzsche, and had a native wit. Georges Duhamel (b. 1884) achieved fame with his psychologically subtle *Salavin* and the series of novels about the Pasquier family. Jules Romains (b. 1885) is best known for his series translated as *Men of Good Will*. André Maurois (b. 1885), whose real name is Emile Herzog, attracted notice with his first novel, *Les Silences du Colonel Bramble* (1918), and produced a long list of novels and biographies, the best known being *Ariel*, his fictional life of Shelley, and *Byron*.

Henri Barbusse (1873–1935) was another novelist who became a celebrity with a war novel, *Le Feu* (Under Fire). Romain Rolland (1866–1945), distinguished as biographer and essayist, produced the vast *Jean-Christophe* (10 vols.), a Nobel prizewinner. Roger Martin du Gard (b. 1881), author of the Thibault family saga, also won the Nobel prize. Morand's cosmopolitan work is very popular, and the poignant tales of Mauriac touch greatness. Fine work

Paul Bourget



Anatole France

Pierre Loti

Marcel Proust

has been done by Cocteau, Bloch, Carco, MacOrlan, Vercel, Lacretelle, Hamp, Bernanos, Malraux, Aragon, Giono, Varende, Jouhaudeau, Kessel, and others.

Jean-Paul Sartre (b. 1905) is the leading Existentialist writer; two of his outstanding works are plays: *Huis Clos* (1944), and *Les Mains Sales* (1945). Jules Romains (b. 1885) is noted for novels of realism particularly *Les Hommes de bonne volonté*. In England the influence of the dramatist Jean Anouilh has been far-reaching.

LESSON 5

Spanish—I: Early Times to the Golden Age

IN poetry and drama, novel, historical romance, and short story, Spanish writers have produced original work of the highest importance, much of which is familiar in translation to English readers. The language in which the main body of Spanish literature has been written is known as Castilian (having been the language of Old and New Castile), which became the established national tongue when Ferdinand and Isabella of Castile had redeemed the country from the last of the Moors at Granada. Portuguese and Catalan have many affinities with Castilian, but both have long held to the status of independent languages.

The Cid

Spanish literature begins with the *Cantar de mio Cid*, a noble epic by an unknown minstrel dealing with the adventures of the warrior Rodrigo Diaz de Bivar (d. 1099); "Cid" is an Arabic title (Sid) meaning "lord." This poem appeared in 1140, and may owe something to the *Chanson de Roland* (11th cent.). French influence was strong at the time, as was Arabic; after the recapture of Toledo from the Moors (1085), Oriental studies were fostered there.

In the 13th century religious poetry flourished, and Gonzalvo de Berceo, a Benedictine monk, wrote his beautiful naive legends of the saints.

Alfonso X of Castile (1252 84), a most enlightened monarch known as "El Sabio" (the Sage), was responsible for compilations of the utmost value, including some from Oriental sources. The *Crónica general* was the first of the numerous chronicles. To *El Sabio* we owe the richly illuminated manuscript of the *Cántigas de Santa Maria*, in the Galician dialect, a treasury of poetry and music. Alfonso's son, the Infante Don Juan Manuel (1282–c. 1349), wrote *Conde Lucanor*, a series of 50 tales skilfully linked together in the manner of *The Arabian Nights*.

Book of True Love

Juan Ruiz (*c.* 1285–*c.* 1350), Archpriest of Hita (near Guadalajara), wrote the delightful *Libro de buen Amor* (Book of True Love), a series of poems linked together in the Oriental fashion and amounting in all to about 7,000 lines. He himself is obviously the central figure, a large, robust man, high-coloured, vital, full of *joie de vivre*. He was evidently ill fitted for the priestly life, for he flits from one love affair to another and is frequently profane. An uncompromising realist, he sees the world as a gay rough-and-tumble, with no chivalry, unselfishness, or purity in it. But his genius is beyond controversy, and he is never dull. He often used the "cuaderna via," a stanza of four lines, each of 14 syllables, with the same rhyme.

In the 15th century the outstanding name is that of the Marqués de Santillana (1398-1458), who, like Don Juan Manuel, led a busy life in the service of his country. A fine scholar and an ardent lover of literature, he wrote charming lyrics and introduced the Petrarchan sonnet into Spain. At the same period Francisco Imperial is noteworthy; his *Dezir a las syete virtudes* is an imitation of Dante.

Chivalrous romance reached Spain from France in the 14th century, *Amadis de Gaul* being best known. In a much shortened and perfected form, this epic material became ballads to be sung to music; many of them were collected in the *Cancionero de Romances* (*c.* 1550). Outstanding in ballad literature is *Conde Arnaldos*, which probably dates from the 16th century.

La Celestina

A most important influence was the *Tragicomedia de Calisto y Melibea* (1499), now known as *La Celestina*, a prose masterpiece of extraordinary power which, for its noble conception, dramatic dialogue, and superb character-drawing, is now recognized as one of the classics of European literature. The author is thought to be Fernando de Rojas, who was mayor of Talavera up to 1538. He tells a story of overpowering love turned to guilty passion by the misdirection of the villainous old woman Celestina, whose avarice at last overreaches itself. Celestina meets her own death at the hands of accomplices whom she has betrayed. This prodigy of evil is one of the most dynamic creations in literature

La Celestina owes something to Juan Ruiz. A forerunner of the picaresque novel, it became extremely popular and was translated throughout Europe. The fine English version by James Mabbe appeared in 1631, but the story was already well known through an anonymous play (1520–30) which may have inspired Shakespeare when he wrote his superb *Romeo and Juliet*.

The beginnings of drama in Spain were much the same as in England and France. The Portuguese Gil Vicente (*c.* 1465–*c.* 1536) was the first important figure. Lope de Rueda (d. 1565) toured Spain with an Italian company presenting "commedia dell' arte"; his own plays show the Italian influence. Juan de la Cueva drew on ballad material which was later to provide inspiration for Lope de Vega and his contemporary Guillén de Castro, author of *Las Mocedades del Cid* (1618), the play that inspired Corneille's *Le Cid*.

The Golden Age

The Golden Age—"Siglo de Oro"—extended roughly from 1550 to 1660. One of its most dazzling luminaries is Lope Felix de Vega Carpio (1562–1635), better known as Lope de Vega. It is interesting to note that he saw active service in the galleon *San Juan*, which sailed with the Spanish Armada and made its way safely home round the coasts of Scotland. Lope wrote his first play at the age of 12. It has been estimated on good evidence that he wrote altogether about 1,600 to 1,800 plays and some 400 autos (one-act plays on religious subjects). This may seem incredible, but he has recorded that 100 of them took no more than a day apiece to write. There actually remain to us 470 plays and about 50 autos, which is a sufficiently astounding total; these were published in an edition of 25 volumes (1604–47). Some of them have historical subjects; others belong to the "comedia de capa y espada," or drama of intrigue, in which the characters wear the cape and sword.

Dramas of Intrigue

Among the best known are *El mejor Alcalde el Rey* (The King's the best alcalde—i.e. mayor), *El Perro del Hortelano* (The Gardener's Dog), and *Fuente Ovejunac* (The Sheep Well), which have been translated, together with a typical cloak and sword play, *Lo Cierto por lo Dudoso* (A Certainty for a Doubt), by J. G. Underhill. *Fuente Ovejuna* is a story of conflict between the common people and their absolutist rulers; it has been played in England as *The Spanish Village*, following a great success in the Soviet Union. The class struggle also appears in *El mejor Alcalde el Rey* and the fine *Peribáñez*. Other plays which have been translated are *La Imperial de Otún* (The Crown of Otun) and *La Dama Boba*. Lope de Vega's main contribution to drama lies in his widening of its scope and in his skilful craftsmanship.

Not only was he a superb dramatist, but as a lyric poet, too, Lope is in the front rank, with an immense output, including 700 sonnets (several were translated by Longfellow) and some exquisite ballads. He also wrote epics, epistles, and pastorals; *Los Pastores de Belén* (The Shepherds of Bethlehem) contains a Cradle Song which is among the gems of Spanish poetry. In prose he was the author of a pastoral romance, *Arcadia*, and other novels. Lope de Vega's non-dramatic works have been collected in 21 volumes. Of verse alone, he wrote several million lines. Well might Cervantes call him a "monster of nature."

On the stage Lope had numerous followers. Juan Ruiz de Alarcón excelled in the comedy of character; his *La Verdad Sospechosa* was the model for Corneille's *Le Menteur*. But the outstanding figure in succession to Lope de Vega was Pedro Calderón de la Barca (1600–81), who wrote about 80 autos and a large number of comedies; *El Alcalde de Zalamea*, *La Vida es sueño*, and *El Médico de su Honra* are especially notable. Calderón's works have been widely translated.

Poetry of the Golden Age

In poetry the Golden Age was heralded by Garcilasso de la Vega (1503–36), a knightly figure who has been compared with our own Sir Philip Sidney. He wrote little, but the rare beauty of his verse sets him among the classics; Cervantes and Lope de Vega regarded him as supreme above all other Spanish poets.

Luis de Góngora y Argote (1561–1627) is so important that he has given his name to the period. Góngora was a great poet in the baroque manner, and much of his work has a rare beauty. It can be said of him paradoxically that graceful artificialities were his natural mode of expression, but, carried to an extreme by imitators who lacked his genius, what was original and effective in him became mere mannerism in them, and "Gongorism," with its inversions, its far-fetched vocabulary, and its conceits, proved to be a harmful influence.

Bartholomé Leonardo de Argensola (1562–1631), a renowned Classicist, wrote pure and noble verse modelled on that of Horace. A more original genius was Francisco de Rioja (*c.* 1583–1659), whose lyrics have the freshness and rare quality of Ronsard or Herrick. Rioja was a canon of Seville and a friend of Lope de Vega. His work remained unpublished until the end of the 18th century.

The Portuguese poet and dramatist Gil Vicente must also be mentioned here, for he wrote in Spanish as well as in Portuguese, and his Spanish lyrics are among the loveliest in the language.

This was the great age of mysticism in Spain ; it produced Friar Luis de León (1528–91), who, whether in poetry or in prose, is one of the glories of Spanish literature ; San Juan de la Cruz (St. John of the Cross, 1542–91), in whom is the very essence of mysticism ; and the anonymous author of a magnificent sonnet, *On Christ Crucified.* In prose, Teresa de Cepeda de Alcumuda, who became Santa Teresa (1515–82), achieved a beautiful blend of idealism and practicality.

CERVANTES. This portrait of Spain's most celebrated writer was first brought to notice in 1911, and was approved as authentic by the Spanish Academy.

The period was extraordinarily rich in fiction. Spain now gave the world a new type of novel, the "picaresca," a novel of manners whose central figure was a rogue ("picaro"). The first picaresque novel pure and simple was *Lazarillo de Tormes,* written by an unknown author in the middle of the 16th century. It had numerous imitators, notably *Guzmán de Alfarache* (1599) by Mateo Alemán, *La Picara Justina* (1605) by Francisco López de Ubeda, and the memorable *Vida del Buscón llamado Don Pablos* (1626) by the satirist Francisco Gómez de Quevedo y Villagas (1580–1645), who attacked vice in his *Sueños* and in other poetic works.

The Italianate pastoral romance, derived from Sannazaro's *Arcadia,* is exemplified in the *Diana* of the Portuguese Montemayor, the *Galatea* of Cervantes, and the *Arcadia* of Lope de Vega.

A third type, the novel of adventure, was also Italian in origin. Cervantes introduced it to Spain in his *Novelas Exemplares,* which consists of 12 "novelli" or short stories translated in 1640 ; two of these stories, *Rinconete and Cortadillo* and *The Colloquy of the Dogs,* are masterpieces. From the adventure novel developed the type which blends social commentary with adventure, as in *Marcos de Obregón* (1618) by Vicente Martínez Espinel (1551–1624), which was the main source of *Gil Blas.*

TWO BELOVED FIGURES. These lifelike statues of Don Quixote and Sancho Panza form part of the monument to their great creator in Spanish Place, Madrid.

Miguel de Cervantes Saavedra (1547–1616), whose world-famous *Don Quixote* appeared in two parts, in 1605 and 1615, was a poet and a dramatist, but undistinguished in either capacity. When he began *Don Quixote,* his object was to destroy by ridicule the spate of romances of chivalry then being published. He found himself so gripped that he went far beyond his original conception, producing a monumental prose-epic, in which the central characters are not mere figures of fun but thoroughly human and lovable, with ideals which we respect. Over 600 characters are introduced ; it deals with two fundamental and conflicting aspects of man's nature—the idealistic and the realistic. Half-crazed with reading romances, Don Quixote conceives himself to be a knight, and sets out to make the world a better place than it is. Sancho Panza, whom he appoints to be his squire, goes with him, and they become involved in ludicrous adventures.

Don Quixote marked the end of medievalism, and heralded the new qualities of observation and analysis which characterise modernism. It set a high standard of prose writing, and so robust is its quality that it seems destined to hold its place for all time. The best English translation is John Ormsby's, though those of Jarvis and Le Motteux are more popular.

History and travel are well represented in this period. In Juan de Mariana (1535–1624) we have the greatest of the Spanish historians. This famous Jesuit was the forerunner of the "scientific" historians of our own times. It has been said of his *History of Spain* that it is "the most remarkable union of picturesque chronicling with sober history that the world has ever seen."

Among the travel-writers Bartholomé de las Casas (1474–1566), bishop of Chiapa, is most important. A friend of Columbus, he wrote a valuable *History of the Indies.*

LESSON 6

Spanish—II: 18th Century Onwards

THE political decline of Spain was accompanied by a period of decay and sterility in literature. No name comparable with the great names of the Golden Age can be recorded during the 18th century. There were, however, three important events: the foundation of the National Library in 1711, of the Royal Academy in 1714, and of the Royal Academy of History in 1738. To these admirable institutions the world is indebted for the conservation of much that is best in the language and literature. The Royal Academy published a magnificent Dictionary in six folios, and afterwards a Grammar.

Ignacio de Luzán, a disciple of Boileau, did much to formalise Spanish literature according to French neo-classic models. His *Poética* appeared in 1737.

There was a dearth of lyric poetry. Juan Meléndez Valdés (1754 1817), leader of the classicists, was an accomplished poet, whose odes, *Los Besos de Amor*, have been highly praised. Memorable, too, are the fabulists Felix Maria Samaniego (1745 1801) and Tomas de Iriarte (1750 91). In drama Ramón de la Cruz y Cano (1731 94) translated *Hamlet* and wrote amusing plays containing a vivid record of contemporary society. Leandro Fernández de Moratín (1760 1828) wrote two outstanding plays, *El Si de las Niñas* and *La Comedia Nueva*, besides admirable essays and verse.

One novel of merit continued the picaresque tradition—*The History of the Famous Preacher Fray Gerundio de Campazos, alias Zotes*, by the Jesuit Josef Francisco de Isla (1703 81).

Romantic Poets

The Romantic revival appears first in the work of the Duke of Rivas, poet and dramatist, and then in the passionate and Byronic figure of José de Espronceda (1808 42), whose tragic love-story is commemorated in *El Diablo Mundo*. The magnificent *El Pirata* is reminiscent of *The Corsair*, and *El Estudiante de Salamanca* is modelled on *Don Juan*. Espronceda has been compared with Swinburne for his mastery of rhythm; this is evinced in the slow harmonies of his *Hymn to the Sun*.

The Byronic influence is also noteworthy in José Zorrilla (1817–93), author of *Don Juan Tenorio*, a play which has taken its place in the national repertory. Zorrilla was also a fine descriptive poet. His work is strongly national.

In the later half of the 19th century the most notable poets are Ramón de Campoamor (1817 1901) and Gaspar Núñez de Arce (1834-1903). Campoamor, a gay man of the world, wrote delightful lyrics, of which *Quién Supeira Escribir*, *El Gaitero de Gijón*, *Lo que hace el tiempo*, and *El Beso* are typical. Núñez de Arce, a Castilian, was the greatest poet of his time. His best work is in the *Gritos del Combate*, *Ultima Lamentación de Lord Byron*, *El Idilio*, *La selva obscura*, *El vertigo*, and *La vision de Fray Martin*.

Other poets of note are Joaquín María Bartrina (1850-80), a follower of Leconte de Lisle; Vicente Wenceslao Querol (1836–89), author of *Cartas á Maria*, and *La Fiesta de Venus*, and José María Gabriel y Galán (1870–1905), whose *El Ama* and *El Cristu benditu* are outstanding

Drama

In drama Ventura de la Vega (1807-65), a disciple of Moratín, wrote *El Hombre de Mundo* in the tradition of Molière. Tamayo y Bans was popular, but he was eclipsed by José Echegaray (1832–1916), an extremely versatile writer who began his career as professor of mathematics, became minister of education and minister of finance, and was a most successful business man. In literature he made his mark as a philosopher and a poet, but he is best known as a dramatist. He wrote over 80 plays, and had a tremendous influence. His early plays are Romantic, but he went on to social drama and also to symbolism. Best known of his plays are *La Esposa del Vengador*, *El Gran Galeoto*, *Mariana*, *El Hijo de Don Juan*, and *El Loco Dios*.

Jacinto Benavente (1866–1939), a prolific and versatile dramatist, dominated the stage for many years. *La Comida de las Fieras*, *La Noche del Sábado*, *Rozas de Otoño*, *Los Intereses Creados*, *La Malquerida*, *La Mariposa*, and *Almas Fuertes* were his most successful plays, ranging from light comedy to powerful tragedy. Several of his plays have been translated by J. G. Underhill; the best known to English and American readers is the lively one-act comedy translated under the title *No Smoking*.

Fiction

A reaction against Romanticism began with Fernán Caballero (1796-1877). She wrote realistic novels in an unassuming style. Pedro Antonio de Alarcón (1833–91) will be remembered for *El Sombrero de Tres Picos* (The Three-Cornered Hat), a charming Andalusian tale, inspired by traditional ballads and song. José María de Pereda (1833-1906) was the founder of the realistic school. His best-loved novel is entitled *Sotileza*

Most important was Juan Valera (1824–1905), professor and politician. He had a tremendous

and lasting success with the idyllic *Pepita Jiménez* (1874), which may be read in translated form. It is an essentially Spanish story, written with much subtlety and humour. Other excellent novels were *El Comendador Mendoza*, *Doña Luz*, *Juanita la Larga*, and *Genio y Figura*.

Another brilliant novelist was Benito Pérez Galdós (1843-1920), who wrote the series of historical novels entitled *Episodios Nacionales* (46 vols., 1873-1912), of which *Trafalgar* is one of the most interesting. Of his other novels the most notable are *Doña Perfecta*, *Gloria*, *La Familia de León Roch*, the beautiful *Marianela*, the Zolaesque *Lo Prohibido* and *Realidad*, the social commentaries *Fortunata y Jacinta* and *Angel Guerra*, and later *La Loca de la Casa*, the *Torquemada* trilogy, *Misericordia*, *El Abuelo*, and *Casandra*.

Outstanding Titles

This was indeed a great period for fiction. Emilia, Countess of Pardo-Bazán (1851-1921), wrote powerful, even brutal, studies of peasant life in *Los Pazos de Ulloa*, *La Madre Naturaleza*, and *De mi tierra*. She was influenced by Zola. Armando Palacio Valdés (1853-1938) won fame with *El Señorito Octavio*, *Marta y María*, *Jose*, *Riverita*, *La Hermana San Sulpicio*, and other stories.

Angel Ganivet (1865-98) will long be remembered for *Los Trabajos del infatigable creador Pio Cid*, and Ramón del Valle Inclán for his *Sonatas*, a series of four novels of unusual interest. Under the dictatorship of Primo Rivera he became a Republican; his *Tirano Banderas* is an incitement to revolt. Later Valle Inclán produced a cycle which has been translated as *Iberian Roundabout*; this castigates the monarchy and the court.

World-wide Reputations

Of world-wide reputation was Vicente Blasco Ibáñez (1867-1928), a realist who depicts glowing romantic scenes and passions in a naturalistic manner. To English readers he is best known by such flamboyant successes as (to give the English titles) *Blood and Sand*, *The Four Horsemen of the Apocalypse*, *The Shadow of the Cathedral*, *Enemies of Women*, and *Mare Nostrum*. His finest work, however, is in his early novels and short stories dealing with his native Valencia; of these *La Barraca* (The Cabin) and *Entre Naranjos* (translated as The Torrent) are outstanding.

Pio Baroja (b. 1872), a Basque, began his career with a volume of short stories, *Vidas sombrías*, afterwards retitled *Idilios Vascos*. This was an immediate success, and was translated as *Shadowed Lives*. He has written many other novels, notably the trilogy translated as *Struggle for Life*, *The Quest*, and *Red Dawn*, which deals with the Madrid underworld, under the influence of Gorki. Spain's most distinguished woman writer, Concha Espina, has produced brilliantly penetrating psychological novels; her best known is *La Esfinge Maragata*.

Ramón Pérez de Ayala (b. 1880), a talented poet, critic, and essayist, is the author of several powerful novels. His first book, *A.M.D.G.*, is an attack on the Jesuit college where he was educated. *Belarmino y Apolonio* and *Tigre Juan* are his masterpieces. Essentially Spanish, they are written in a highly individual style, with an enormous vocabulary; this makes them difficult, if not impossible, to translate. Another novelist of distinction is Gabriel Miró (1879-1930), who wrote of his native Alicante in slow, reposeful prose. *El Humo Dormido* and *Figuras de la Pasión del Señor* are his best works. Notable, too, is Salvador de Madariaga (b. 1886), who was professor of Spanish Studies at Oxford 1928-31, and then Spanish ambassador to the U.S.A. Under the pseudonym "Julio Arceval," he wrote the satirical *Arceval y los Ingleses* and *La Jirafa Sagrada*; the latter was first published in English as *The Sacred Giraffe*.

Thinkers, Dramatists, Poets

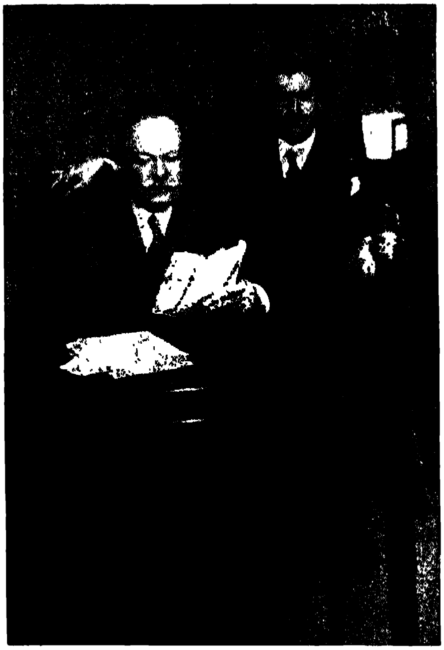
Within recent times a dominant figure has been Miguel de Unamuno (1864-1937), professor of Greek literature and subsequently rector at Salamanca University. A mystic, he combined the most spiritual elements of Eastern and Western thought in an attempt to harmonise man with the universe. His masterpiece is *Del Sentimento Trágico de la Vida*, of which there is an excellent translation, *The Tragic Sense of Life*. The *Vida de Don Quijote y Sancho* is also famous. Unamuno wrote essays, treatises, novels, verse, and a play (*Fedra*).

Drama has flourished in the 20th century, the work of Benavente being supplemented by that of other excellent dramatists. The brothers Alvarez Quintero (Serafín, 1871-1938; Joaquín, 1873-1944), who worked in collaboration, produced a long list of comedies, in which "the tears of things" are often blended with the humour. There are excellent translations by Helen and Harley Granville-Barker of *Puebla de las Mujeres* (The Women's Town), *El Centenario* (A Hundred Years Old), *Fortunato*, and *La Consulesa* (The Lady from Alfaqueque).

Another dramatist who is appreciated in England, Gregorio Martínez Sierra (1881-1947), usually wrote in collaboration with his wife; several of their plays have been translated, the most famous being *Canción de Cuña* (Cradle Song), *Navidad* (Holy Night), *El Reino de Dios* (The Kingdom of God), and *Sueño de una noche de Agosto* (played in English as *The Romantic Young Lady*). More recently Jacinto Grau came to the fore; *El Conde Alarcos*, and *El Hijo Pródigo* made a considerable impression.

Of the modern poets, Rubén Darío (1867–1916), a Nicaraguan, has been named "the apostle of beauty." Much of his work was written under the influence of the French Symbolists, and its enchantment lies in its evocative power. Darío was a consummate artist, with a rare command of rhythm. His chief work is contained in three volumes, *Prosas profanas*, *Cantos de Vida y Esperanza*, and *El Canto errante*.

The early work of Francisco Villaespesa (b. 1877) was influenced by Darío, but this poet developed individually and became one of the greatest of Spanish lyric poets. His *In Memoriam* for the death of his wife is exquisite.



THE BROTHERS QUINTERO. **Widely known are the plays of Serafín (left) and Joaquín (right) Alvarez Quintero, written in collaboration. Witty comedies, they are made memorable by their depth of feeling and piquancy of situation.**

The Machado brothers (Manuel, b. 1874; Antonio, 1875–1939) are scholarly poets and dramatists. Manuel has written accomplished verse of a French elegance; Antonio, renouncing the traditional graces of style, achieved strength and beauty in his *Soledades*, *Campos de Castilla*, and *Poesías*.

Mentioned earlier for their work in other fields are Unamuno, whose *Rosario de Sonetos Líricos*, and *El Cristo de Velazquez* are truly Spanish in inspiration and style; Ramón del Valle Inclán, whose *Marquesa Rosalinda* is outstanding for its mastery of the intricacies of rhythm; Ramón Pérez de Ayala, whose *La Paz del Sendero*, *El Sendero Innumerable*, and *El Sendero Andante* are beautifully harmonious, and to some extent influenced by Walt Whitman; and Salvador de Madariaga, who produced in *Romances de Ciego* a fine poetic work. Madariaga revived interest in Spanish folk-song, of which he made a keen study.

In recent times the most striking poet is Federico García Lorca (1897–1936), whose republican sympathies caused his assassination. He was a poet who would surely have inspired modern Spanish literature to new ventures, as he was in no sense derivative, though some slight influence from Walt Whitman, both in thought and in form, might be traced. He directed La Barraca, the university theatre, wrote plays, and became Spain's most popular poet and widely known abroad. His writing displays powerful imagery, an obsession with mortality; his plays show a blending of dream with reality typical of the highly imaginative. Perhaps his most characteristic work is in *Yerma* (1934), a moving drama of a barren woman, and in his great lament for a bullfighter, *Llanto por Ignacio Sánchez Mejías* (1935), which is one of the most original poems of this century.

Catalan Literature

A brief account must be given of Catalan literature, which in its early days was closely related with that of Provence. Catalan poets until late in the 13th century used the "langue d'oc" and the poetic forms of the Provençal troubadours. This may be seen in the mystic verse of Raymond Lully (1235–1315), known also as Ramón Lull, who also wrote didactic prose.

Gradually the Catalan language discarded Provençal elements, and in the 15th century there was a great outburst of native Catalan poetry, to which the chief contributors were Auzias March (1379–1459), whose *Cants d'amor* and *Cants de mort* mark the apex of Catalan achievement, Joan Roiç de Corella (1430–1500), author of the *Tragedia de Caldesa*, and Jaume Roig (d. 1478), who wrote the *Spill des dones*, a satire on women. Soon, however, the ascendancy of Castile was marked by the fact that a Catalan poet, Juan Boscán, was one of those who founded a new Italianate school of poetry in the Castilian tongue. Catalan lapsed almost to the level of a dialect, producing in the 16th century a graceful poet, Pere Serafí, but, except for a few antiquarians, uninteresting until the revival during the 19th century.

Then, among many other poets, appeared the mystic Jacinte Verdaguer (1845–1902), author of a noble epic, *L'Atlántida*, on Columbus; Tomá Aguiló and Miguel Costai Llabera, writing of their native Majorca; and Joan Maragall, a truly great poet.

In prose the outstanding writer was Eugeni d'Ors ("Xenius"). Of the dramatists Angel Guimerá became famous with *Terra baixa* (1896); he wrote a great many plays with a wide range of interest. Ignacio Iglesias was influenced by Hauptmann, later by Maeterlinck, then turned to comedy.

LESSON 7

Portuguese—I: The First Six Centuries

PORTUGUESE is a literary language in the fullest sense, and since the end of the 11th century it has served as the literary vehicle of a people who are as different from the Spaniards as are the French. Their language is further removed from Latin than Castilian (Spanish); and it has many notable analogies with French.

As in other countries, the development of poetry preceded that of prose. In Portugal the earliest poetry is the lyric, not, as in France, the epic. The indigenous "cossantes," dating from the 12th century, was followed by the poetry of the Provençal troubadours, and during the 13th century the Portuguese poets adapted Provençal forms. Their work was rediscovered during the late 19th century; until then it had been hidden away in libraries. The three great collections of this exquisite poetry are the *Cancioneiro da Vaticana*, *Cancioneiro Colocci-Brancuti*, and *Cancioneiro da Ajuda*. The word *Cancioneiro* means "song-book."

CAMOËS. The greatest figure in Portuguese literature, Camoës achieved fame with his epic, the "Lusiads," which glorifies his country and its empire overseas. Camoës had a troubled life, enduring hardship and imprisonment, and he died a poor man.

Gil Vicente

The first dramatist of any note in Portugal was Gil Vicente (*c.* 1465–*c.* 1536), a man of the people, whose broad humanity and lyric gifts won wide popularity. Altogether 43 of his plays survive; many of them are "autos," comparable with the mystery plays and moralities of English literature, and farces. The *Auto da Barca do Inferno* (The Ship of Hell) is the story of a ship bound for the next world, whose passengers do not know that they are dead. Vicente was as important in Spanish literature as in Portuguese: 11 of his plays were written in Spanish, and he wrote lyrics which are exquisite Spanish poetry. He and his many followers are known as the Eschola Velha. After his death the Jesuits proscribed this popular drama because of its tendency to coarseness, and strictly classical plays became general. Antonion Ferreira (1528–69) excelled in this type; his *Inés de Castro* is an early masterpiece.

The prose comedies of Jorge Ferreira (*c.* 1515–*c.* 1563) were a new development, inspired by the Spanish *Celestina*. *Eufrosina* gives a delightful picture of Portuguese life.

Of epic poetry the outstanding achievement is the *Lusiads* of Luis de Camoës (1524–80). Camoës (or Camoens) came of good family and was educated at Coimbra University. He became popular in Lisbon society, and was soon known to be an accomplished poet, but because he sought to win the love of one of the Queen's ladies-in-waiting, and because of indiscretions in an early play, *El Rei Seleuco*, he was banished from the court of João III. Camoës fought against the Moors in North Africa and lost an eye. In 1552 he was back in Lisbon, but again he was in trouble owing to a quarrel with a court official. He was pardoned only on condition that he took service in India, at the Portuguese settlement of Goa, an experience which brought him great disillusionment. For 16 years Camoës was engaged in expeditions and military campaigns, undergoing privations and imprisonment for debt. During this time he wrote sonnets and verses and worked on the *Lusiads*. In his own words, "One hand the pen and one the sword employed." When at last in 1570 he returned to Lisbon, unknown and impoverished, it took him two years to get his great epic published.

Camoës' Masterpiece

Os Lusiadas (The Feats of the Lusitanians) derives its name from Lusitania, the Latin name for Portugal. The theme is Vasco da Gama's voyage from Portugal round the Cape of Good Hope to discover India (1497–99). Camoës weaves into his stirring narrative the whole proud history of the Portuguese people. This masterpiece is divided into ten cantos containing 1,102 stanzas of eight lines, rhymes occurring in the first, third, and fifth, the second, fourth, and sixth, and the seventh and eighth. The English translation by Mickle still holds the field; Aubertin's is more accurate and almost as readable, and Sir Richard Burton's has many admirers. Camoës wrote much else: sonnets, elegies, songs, odes, and roundels, besides plays.

Bucolic poetry began with Bernardim Ribeiro (1482–1552), who wrote naturally and with passion. Cristovam Falcão (*c.* 1512–*c.* 1553)

excelled in the same genre, as did Francisco **Rodriguez Lobo** (*c.* 1580-1622), author of *A Primavera*, which mingles prose and poetry.

The earliest literary prose dates from the 14th century and consists mainly of chronicles, lives of the saints, and renderings of the Arthurian legend. Of the chroniclers Fernão Lopez (*c.* 1380 *c.* 1460) has been called the father of Portuguese history ; he is immensely vital, with Froissart's sense of the dramatic and the picturesque, but with a more philosophical background.

The Renaissance came to Portugal in part through Spain, in part directly from Italy. An important influence was the poet and dramatist Sá de Miranda (1485 1558) ; he had the advantage of several years' residence in Italy. From him sprang an " Italian school " (*Os Quinhentistas*), in which are the beginnings of modern Portuguese prose literature.

In Portugal the classical epoch falls into three divisions : (1) the Italian school of the 16th century, (2) the Gongorist school of the 17th, (3) the French school of the 18th, leading to a Romantic school of the 19th century, akin to German and French Romanticism and in turn leading to the mixed literature of the present day.

Romances

In prose, the 16th century (the century of Camoès) produced the romance known from its opening words as *Menina e moça*, by the poet Bernardim Ribeiro. In the same vein Jorge de Montemôr, or Montemayor (*c.* 1518 61), wrote his more famous *Diana* ; this, however, was in Spanish, and was based largely on the *Arcadia* of the Italian Sannazaro (1458-1530), which had set the fashion for pastoral romance throughout Europe. The *Lusitania Transformada* of Fernam Alvarez do Oriente (*c.* 1540-*c.* 1595) should also be noted. Francisco de Moraes (*c.* 1500-72) wrote a lively *Chronica de Palmeirim de Inglaterra*, much admired by Cervantes, and Fernandez Trancoso (*c.* 1515-*c.* 1590) made an exceedingly popular collection of " contes," based mainly on Italian stories.

Travel Literature

In the 16th and 17th centuries travel literature was abundant. One could make a formidable list of at least a hundred names of intrepid travel-authors, beginning with Alvaro Velho, who kept the log of Vasco da Gama's voyage in 1492, and ending with Manoel Godinho (*c.* 1630-1712). Some of them were explorers ; some were Jesuit missionaries. The most remarkable is Fernão Mendes Pinto (*c.* 1510 83). During twenty years this courageous and observant man travelled in Ethiopia, Arabia, India, China, Japan, Tartary, and the East Indies. On thirteen occasions he was taken prisoner. He suffered the greatest hardships, in all of which he never abandoned his notebook. The result he gave to the world in his *Peregrinations*, which, written in a style of extreme simplicity and force, is in Portugal one of the most popular of all travel books. It has been translated into English, German, French, and Spanish.

João de Lucena (1550-1600) wrote a history of the life and travels of Fr. Francisco Xavier, the missionary ; containing " many curious things concerning Asia," it is one of the classics of the language. Also to be mentioned are the celebrated *Historia Tragico-Maritima*, twelve contemporary accounts of shipwrecks, afterwards collected by Bernardo Gomes de Brito (1735-36).

History and Religion

The expansion of the Portuguese Empire inspired the writing of numerous histories. João de Barros (*c.* 1496 *c.* 1570) has been called Portugal's Livy. His best known work is *Asia* ; he wrote three out of a projected four parts, which were extended to 12 parts by Diogo do Couto (1542 1616), who was the better writer of the two. Fernam de Castanheda and Gaspar Corrêa, contemporaries of Barros, also gave vivid accounts of India. In the 17th century came Pedro Paez's *History of Ethiopia* ; he had spent 10 years in the country and wrote the first description of the sources of the Nile. Manoel Barradas and Manoel de Almeida also wrote of Ethiopia ; all three were Jesuit priests. Another Jesuit, Balthazar Tellez, wrote a history of the order (*Cronica da Companhia de Jesus*).

Religious writings flourished during the 16th and 17th centuries. The beautiful *Trabalhos de Jesus* of Frei Thomé de Jesus (1529-82) have been compared with *The Imitation of Christ*.

The most notable author of the 17th century was D. Francisco Manoel de Mello (1608 66), but he wrote mainly in Spanish. His range was wide, including histories, literary criticism, portraits, maxims, verse, and a witty play, the *Auto do Fidalgo Aprendiz*. Another classic writer, the Jesuit Antonio Vieira (1608 97), was famous for his *Sermões* and for the strange *Historia do Futuro*.

The well-known *Cartas de uma Religiosa Portugueza* first appeared in French in 1669 ; it was not until 1819 that the Portuguese version was published. They were written by the nun Marianna Alcoforado to a French lover who deserted her.

Gongorism

The 17th century is known as the Gongorist period, because it was influenced by the Spanish poet Luis de Góngora. Gongorism came to mean an affected elegance, a striving after the unusual. Góngora himself was a man of genius, in whom the unusual was, generally speaking,

felicitous, but his followers merely produced *cultismo*, a style consisting of inversions, complexities, forced meanings, hyperbole, and over-profusion of vocabulary.

In the 18th century the most important literary events are the foundation of the Royal Academy of History (1720); the Royal Academy of the Sciences (1780); the Arcadia Lusitana, or Arcadia Ulyssiponense (1756), a society modelled on the Italian Arcadia, for the encouragement of good taste in poetry; and the Nova Arcadia (1790). The literature of the period is alternatively known as the French or Arcadian school.

In poetry one should note Pedro Antonio Corrêa Garção (1724–72), chief of the Arcadians, whose *Cantata de Dido* is his outstanding work; Domingos dos Reis Quita (1728–70), a charming bucolic poet; Antonio Dinis da Cruz e Silva (1731–1799), whose racy satire *O Hyssope*, derives from Boileau's *Lutrin*; Manoel Maria de Barbosa du Bocage (1765–1805), José Agostinho de Macedo (1761–1831), and Francisco Manoel do Nascimento (1734–1819), whose reputations have declined; Nicolao Tolentino de Almeida (1741–1811), a gifted satirist, and Belchior Manoel Curvo Semedo (1766–1838), leaders of the Nova Arcadia.

LESSON 8

Portuguese—II: 19th-Century Romanticism

ROMANTICISM dominated the 19th century in Portugal, and one of its greatest exponents was Viscount Almeida Garrett (1799–1854), a strange figure who made his mark in politics. He set out to give Portugal a national drama, to which he contributed several fine plays on Portuguese themes, notably *Auto de Gil Vicente*, *Alfageme de Santarem*, and the outstanding *Frei Luis de Sousa*. The best of his lyric verse, collected in *Flores sem Fructo* and *Folhas Cahidas*, is exquisite; his longer poems include *Camões* and *Dona Branca*, which did much to establish Romanticism. In prose, too, Garrett excelled; the historical novel *O Arco de Santa Anna* was written under the influence of Sir Walter Scott; *Viagens na minha terra*, the account of a journey to Santarem, is a real masterpiece.

The historian Alexandre Herculano (1810–77) wrote verse which has grandeur and intense sincerity, as well as novels inspired by Scott but remarkable for an eloquence all his own. He had numerous imitators. Another historian, Joaquim Pedro de Oliveira Martins (1845–94), though less reliable, has a vigorous and colourful impressionistic style. Atenro de Figueiredo (b. 1867) was his distinguished follower.

Impressionism imbues the work of Camillo Castello Branco (1825–90), who wrote novels and short stories of contemporary life, sometimes lacking depth or probability but lit with genius and nearly always perfect in style.

Romantic Poetry

Of the Romantic poets Antonio Feliciano de Castilho (1800–75) wrote in a flowing natural style. José da Silva Mendes Leal (1818–86), noted for his patriotic verse, was also successful as a dramatist and a novelist, as was the sentimental poet, Francisco Gomes de Amorim (1817–92), biographer of Garrett. João de Lemos (1819–89) wrote musical and scholarly verse, which was collected in his *Cancioneiro*, and Antonio Augusto Soares de Passos (1826–60), author of the melancholy *Poesias* and other volumes, stimulated the Romantic movement also by his translation of Ossian. Thomaz Ribeiro (1831–1901) in a crowded life found time to produce patriotic verse; *Don Jayme* (1862) is his finest achievement. Raimondo Antonio de Bulhão Pato (1829–1912), a voluminous writer of pleasant verse, spent about 40 years in writing his *Paquita*, which is somewhat in the manner of Byron's *Don Juan*.

Reaction from Romanticism

There was, of course, a reaction from Romanticism. This is seen particularly in the novels of the second half of the century. Joaquim Guilherme Gomes Coelho (1839–71), writing as Julio Diniz, became famous at the age of 21 with *Uma Familia Ingleza*, a Dickensian novel. *As Pupillas do Senhor Reitor* and other stories are chronicles of village life, wonderfully suggestive of Jane Austen.

Portugal's greatest novelist was José Maria de Eça de Queiroz (1843–1900), founder of the realistic school, a most original writer with a powerful imagination and much charm of manner. He wrote *O Crime do Padre Amaro*, *O Primo Bazilio*, *Os Maias*, *A Reliquia*, *A Correspondencia de Fradique Mendes*, *A illustre Casa de Ramires*, and *A Cidade e as Serras*, besides his masterly short stories. Eça de Queiroz was influenced by the French realists, but there was in him a vein of mysticism. His most important disciple is Aquilino Ribeiro, author of *A Via Sinuosa* (1918), *Filhas de Babilonia* (1925), and *Estrada de Santiago* (1925).

Other novelists who should be noted are Manoel da Silva Gayo, author of a masterly "conto," *Peccado Antigo* (1893), and of *Ultimos Crentes* (1904); Teixeira de Queiroz

(1848–1919), a prolific writer of naturalistic novels and "contos"; Jaime de Magalhães Lima, who wrote novels with a purpose and also "contos"; Manoel Teixeira Gomes, an artist in prose, with the gift of vivid characterisation; Raul Brandão, who wrote the magnificent *Pescadores* and *Os Pobres*; Manoel Ribeiro, best known for his great trilogy, *A Catedral*, *O Deserto*, and *A Resurreição*; and the political satirist Campos Monteiro, whose *Saude e Fraternidade* will be remembered. There has been a rich crop of short stories. José Francisco de Trindade Coelho (1861–1908) was the best of the "contistas." His work, collected in *Os Meus Amores* (1891), blends realism and idealism in delightful fashion and shows a sympathetic insight into peasant life.

Historians and Literary Critics

Of the historians and literary critics Joaquim Theophilo Braga (1843–1924), a most industrious writer and editor, rendered immense services to Portuguese literature. This distinguished statesman became the first president of the Portuguese Republic. Professor Fortunato de Almeida produced an admirable *Historia de Portugal* and *Historia da Igreja em Portugal*.

Drama has continued to lack vitality. Its most notable exponents have been D. João da Camara (1852–1908), whose plays cover a wide range—historical, social, melodramatic, or fanciful in type; Marcellino Mesquita (1856–1919), author of moving historical tragedies and problem plays; Henrique Lopes de Mendonça, whose historical plays are excelled by his realistic prose plays; and Julio Dantas, who re-created the past with exquisite effect in such plays as *A Severa* and *Soror Mariana*.

Post-Romantic Poetry

In poetry Anthero de Quental (1842–91) led the revolt against Romanticism; his sonnets ensure his immortality. Quental was profoundly influenced by German literature. A one-time student of Coimbra University, he founded the Coimbra school of poets, to which Professor Braga belonged. Braga himself wrote the epic *Visão dos tempos*. The most natural of Portuguese poets, João de Deus (1830–96), wrote lyrics of unsurpassed beauty and simplicity; his work was collected in *Campo de Flores*. Antonio Candido Gonçalves Crespo (1846–83), in two slender volumes, *Miniaturas* and *Nocturnos*, left poems so faultless that he is to be reckoned among the immortals.

Another fine poet, Abilio Manoel Guerra Junqueiro (1850–1923), was an enthusiastic admirer of Victor Hugo, whose influence was strong in Portugal. Guerra Junqueiro's first volume of poetry was published when he was only 14. He won fame with the ironic *A Morte de Dom João* (1874). Patriotism inspired some of his verse, but the most moving deals with peasant life. Antonio Duarte Gomes Leal (1849–1921) is at his best in the same genre, though there is brilliance in his *Claridades do Sul* and in the well-known *O Anti-Christo*.

Verse of Rare Perfection

José de Sousa Monteiro (1846–1909) and Antonio Feijó (1862–1917) wrote verse of rare perfection. Cesario Verde (1855–86) was a poet who chose themes of natural appeal. Antonio Nobre (1867–1900), a poet with a superb command of metre, had considerable influence with his remarkable medley *Só* (1892), which is imbued with melancholy.

The Conde de Monsaraz (1852–1913) and Augusto Gil excelled in poems of the open air. Another nature poet is Joaquim Teixeira de Pascoaes (b. 1877), who founded the school "Saudisismo," reviving the cult of "saudade" and whatever was characteristically Portuguese; he is a pantheist. João de Barros, known also as a politician, wrote much stimulating verse and prose. Antonio Corrêa de Oliveira (b. 1880) was a true lyric poet, racy, of the soil. Afonso Lopes Vieira was inspired by the sea.

The Galician Revival

The Galician language is regarded as a branch of Portuguese, and it was used for literary purposes during the Middle Ages, notably by Alfonso the Sage in his *Cantigas de Santa Maria*, but there was little true Galician literature until the great revival during the 19th century.

Among the early poets Alberto Camino (1821–61) produced a small volume of impeccable verse, *Poesias Gallegos*, which was not published until 1896. Rosalía de Castro (1837–85) became famous for her *Cantares Gallegos* and *Follas Novas*, which touch perfection. The blind Valentin Lamas Carvajal (1849–1906) gives a vivid picture of peasant life, notably in *Espiñas*, *Follas e Frores*, *Saudades Gallegos*, and *A Musa d'as Aldeas*. The raciness of Benito Losada (1824–91) made him popular.

Eduardo Pondal (1835–1917), a unique, Ossianic figure, primeval despite his culture, wrote poetry which has a strange aloof grandeur, tenderness, mystery, and wild music. Sometimes it is no more than a sentence, but it has incantational power. Manoel Curros Enriquez (1851–1908), Manoel Núñez Gonzalez (1865–1917), Antonio Noriega Varela, and Xavier Prado express the soul of a people who delight in song. In prose there are excellent volumes of "contos."

LESSON 9

Italian: Middle Ages, Renaissance, and Modern

The Italian language is a modification of Latin. For the development of a vernacular literature in Italy, the Tuscan dialect was to prove itself the best medium. Towards the end of the 12th century the Provençal troubadours had revealed the potentialities of their own vernacular; many of them were established as court poets in the kingdoms of north Italy. In Sicily, about 1220, Frederick II founded a school of poets under Provençal influence, using a vernacular which resembled the Tuscan. Soon court poetry was flourishing on the mainland, especially in Tuscany and the Romagna, and by the middle of the 13th century many poets were writing in the Tuscan.

DANTE. This portrait of Dante as a young man (right-hand figure) is from Giotto's fresco in the Bargello, Florence. It is the only likeness made during his lifetime. Giotto was his friend, and he depicts an assembly of saints among whom are the leading Florentines.

Italian Verse Forms

Among the new metrical forms evolved the most common were the *canzone* (can-tso-nay) and the sonnet. The canzone followed a definite rhyming pattern, exemplified in these lines from D. G. Rossetti's translation of a poem by Guido Cavalcanti, quoted by Garnett:

> But when I looked on death made visible,
> From my heart's sojourn brought before mine eyes,
> And holding in her hand my grievous sin,
> I seemed to see my countenance, that fell,
> Shake like a shadow: my heart uttered cries,
> And my soul wept the curse that lay therein.
> Then Death: "Thus much thine urgent prayer shall win—
> I grant thee the brief interval of youth
> At natural pity's strong soliciting."
> And I (because I knew that moment's ruth
> But left my heart to groan for a frail space)
> Fell in the dust upon my weeping face.

The sonnet also had a definite pattern; it consisted of an octave, rhyming ababbaba, and a sestet, which allowed a certain amount of variety in the rhyme-scheme. The *ballata*, the *ottava rima*, and the *sestina* were also much used; examples are in Rossetti's translations. Byron made frequent use of the *ottava rima*.

Of the early Tuscan poets Guido Cavalcanti (*c.* 1250–1300) and Cino da Pistoia (1270–1336) are most important. Cavalcanti, a friend of Dante, wrote one of the best known of all canzoni, *Donna mi prega*. Da Pistoia wrote love poetry which for tenderness and psychological subtlety has been surpassed only by Dante's. In Dante (1265–1321) both poetry and prose found a master. *La Divina Commedia* gives him a place in the front rank of the world's greatest poets. His *Vita Nuova*—the story of his love for Beatrice—is the first notable work in Italian prose. Some of his lyrics, canzoni, and sonnets are masterpieces.

Enough is known of Dante's family background to establish that he came of an old and well-to-do family; that he had for a teacher Brunetto Latini, the most learned of contemporary Florentines; and also that as a young man he took part in several military campaigns. He became chief magistrate of Florence, and this brought him into contact with princes and even with the pope, whom he visited in 1302 in connexion with a local political feud. During his absence enemies obtained a sentence of exile against him, with confiscation of his property and a threat of burning if captured alive. From then onwards until his death he wandered from the court of one princeling to that of another. He had a wife, Gemma Donati, and a family; they did not accompany him into exile. He makes no mention of Gemma in his works, but in both verse and prose he continually revived the memory of the lady Beatrice, whom he worshipped from a distance; she was married, and died young. The *Vita Nuova* is verse in a prose setting—or prose decked out with verse. It is a memorial to Beatrice, and relates the course of Dante's platonic love for her. The *Convivio*, or *Banquet*, is a continuation of the *Vita Nuova*. Beatrice becomes the symbol of philosophy.

It is, however, the stupendous achievement in *La Divina Commedia* which places Dante in the category of Homer and Shakespeare, and

makes him a successor of the poets of classical antiquity and of the Old Testament prophets. The whole work is divided into three parts: *L'Inferno*, *Il Purgatorio*, and *Il Paradiso*. It is a spiritual allegory in which Virgil conducts Dante through Hell and Purgatory towards the Earthly Paradise, from which Beatrice leads him on to an anticipation of the vision of supreme beatitude in the Empyrean Heaven.

Here is the whole religious philosophy of the Middle Ages presented with superb artistry, a pregnant conciseness of style, a perfect balance of thought and language, and a harmonising of the new Italian tongue which the poet brings to complete maturity.

Dante can say in a few words what another poet would take many lines to say. His achievement is the greater because he was not satisfied to accept any existing metrical form for it, but invented his own—the wonderful *terza-rima*, lines of ten or eleven syllables arranged in sets of three. The middle line of the first group rhymes with the first and third lines of the second, the middle line of the second rhymes with the first and third of the third group, and so on. At the end of a canto, to round it off, there is an extra line rhyming with the middle line of the preceding group. Dante called it "Commedia" because in the classical tradition every story which ends happily is a "comedy."

Petrarch and Boccaccio

Francesco Petrarch (1304–74) is the greatest lyrical poet in the Italian language. His fame rests on his *Canzoniere*, a collection of exquisite lyrics, canzoni, and sonnets which bring Italian measures to their finest technical perfection. Several of these poems are dedicated to Laura, a lady whom he loved and revered from a distance as Dante loved Beatrice.

Giovanni Boccaccio (1313–75) is the third of this great triumvirate of Italian letters. He is famous the world over for *Il Decamerone*, in which seven ladies and three gentlemen, to escape the horrors of the plague in Florence, retire to a house in the country and beguile the time by telling stories for a period of ten days. These stories are highly entertaining, and at times improper, but few of them were of Boccaccio's own invention, and the licentiousness lies in the original source.

The importance of the *Decameron*, apart from its sheer entertainment value and the fact that it was the first work of considerable size in a perfected Italian prose, is that with it modern fiction came into being. None is better than Boccaccio at telling a tale. The introductory passages are little masterpieces, characters are delineated with great skill, and the whole work is written in a narrative style which moves rapidly to a well-founded conclusion. Boccaccio wrote also two epics—*Filostrato* and the *Tesiad* (or story of Theseus). Chaucer based his *Troilus and Creseyda* on the former; from the latter he took his *Knight's Tale*.

Lorenzo de' Medici

The Academy at Florence fostered the study of the Latin and Greek classics, and Lorenzo de' Medici (1448–92), its rich and intelligent patron, besides encouraging others to write was himself a graceful poet. When the German Gutenberg invented printing about the middle of the 15th century, Italy became the headquarters for the printing of all the books that mattered. Thus the Renaissance, or "re-birth" of learning, first took place in Italy; afterwards it spread through France into Spain, Holland, Germany, England and other countries. The importance of this movement is that it was the mainspring of modern Western culture.

Lorenzo de' Medici's favourite companion, the scholarly Poliziano (1454–94), was the first to write a play in Italian on a secular subject; *Orfeo* is lyrical tragedy, set to music, and it is the forerunner of opera. Count Matteo Maria Boiardo (1434–94) wrote *Orlando Innamorato*, a delightful large-scale romance of chivalry, which

RENAISSANCE WRITERS. The portraits of these great figures, Petrarch (left) and Boccaccio (right), were painted by Andrea del Castagna and were originally in the convent of St. Apollonia. The two men were close friends, and shared a deep admiration of Dante

National Museum, Florence ; photo, Alinari

was the highest verse achievement of the century. Orlando is better known as Roland, the "preux chevalier" of Charlemagne's court; he was also the hero of *Morgante Maggiore*, the forerunner of modern burlesque poetry (not without its serious side), by Luigi Pulci (1432–87).

Another humorous poet who should be noted is Francesco Berni (1497–1535), who had an amazing mastery of language. Jacopo Sannazaro (*c.* 1458–1530) is famous as the author of a pastoral romance in prose and verse named *Arcadia*. In Francesco Guicciardini (1483–1540) Italy found her first great historian. He records events in Italy during his lifetime. Guicciardini was a patriot, and he was also a forthright realist.

Baldassare Castiglione (1478–1529) wrote the famous *Cortegiano* or *Courtier*, a picture of high society in excellent prose. From Giorgio Vasari (1512–74) came the *Lives of Great Painters*, and Benvenuto Cellini (1500–71) has given us one of the few great autobiographies in literature, a work of absorbing interest that bears the stamp of objective truth.

Machiavelli and Ariosto

Few writers have been more disliked than the Florentine, Niccolò Machiavelli (1469–1527). His best-known work is *Il Principe* (The Prince), which should be read in conjunction with his *Discourses on the First Decade of Titus Livius*, from which it is a development. *The Art of War* is a practical treatise. *The History of Florence* is commentary rather than history. Machiavelli looked for the regeneration of Italy, the expulsion of the foreigner, and the establishment of a strong, unified rule. As a solution of his main problem he imagined a prince as figurehead, surrounded by wise and determined advisers who would stop at nothing in their struggle to achieve freedom and good administration. Regarded from another angle, *The Prince* may seem a diabolical book, a manual for unscrupulous tyrants.

In the same period lived Ludovico Ariosto (1474–1533), whose *Orlando Furioso* is an imperishable work of poetic imagination which places him next after Dante among Italian poets. This romantic epic shows, as a subsidiary episode, Orlando (Roland) being driven mad (*furioso*) by his unrequited love for the lady Angelica, who loves and is beloved by his friend Rinaldo. It is, in a sense, a sequel to the *Orlando Innamorato* of Boiardo, but we have now a master-craftsman elaborating the theme in a succession of thrilling episodes of chivalry. The interest is shifted to a new pair of lovers, from whom the house of Este, whom the poem glorifies, traced their descent.

Torquato Tasso

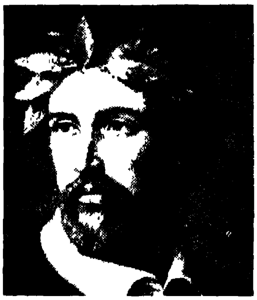
From Ariosto to Torquato Tasso (1544–95) is not a great step in time. Tasso's *Gerusalemme Liberata*, dealing with the capture of Jerusalem by the Crusaders, is a chivalrous epic which glorifies Italy as the centre of Catholic Christendom. Tasso's genius first revealed itself at the age of 18, when he produced a romantic epic, *Rinaldo*, inspired by Boiardo and Ariosto. Later he wrote the exquisite *Aminta*, which was the first important pastoral drama in poetry and had influence on the development of opera.

The old *commedia dell' arte*, or comedy of masks, had persisted from the time of the Romans. They had inherited it from the Greek countryfolk who worshipped the wine-god Dionysus with mime and song. The stories were traditional, and there were stock characters, including Columbine, Harlequin, Pantaloon, and Punchinello: the speeches were often impromptu. Count Carlo Gozzi (1720–1806), in a series of fairy-tale fantasies, embodied the true spirit of the *commedia dell' arte*, which had never before taken literary shape. Meanwhile the musical drama had begun in earnest with Pietro Metastasio (1698–1782), in whom the qualities of poet and dramatist were happily blended. Among his plays the most successful were *Achille in Sciro*, *Clemenza di Tito*, and *Attilio Regolo*.

The first Italian dramatists to achieve a European reputation were Carlo Goldoni (1707–93) and Count Vittorio Alfieri (1749–1803). Goldoni drew his characters from life, providing

Niccolò Machiavelli

Ludovico Ariosto

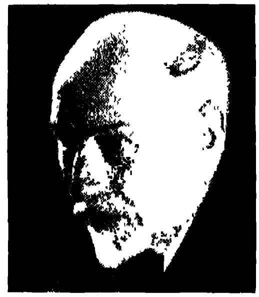


Torquato Tasso

Vittorio Alfieri

Alessandro Manzoni

Giacomo Leopardi



Luigi Pirandello

Benedetto Croce

them with witty and vivacious dialogue. Of his comedies, the best known are *La Bottega di Caffè*, *Pamela Nubile*, *Gli Innamorati*, *Il Bugiardo*, and *La Locandiera*.

Alfieri is the greater dramatist, and he was also, in his passionate desire for liberty, the herald of a new Italy. He wrote a score of tragedies inspired by the revolutionary spirit; outstanding are *Saul*, *Myrrha*, *Abel*, *Philip the Second*, and *The Conspiracy of the Pazzi*.

The poet Vincenzo Monti (1754–1828) reflects the fluctuating emotions of his day. Monti was an impressionable man, one day swayed by the passions of the moment, next day capable of a Dantesque objectivity. He wrote thundering verse against superstition, and impressive odes in favour of Italian unity. The only two names which can be mentioned with that of Monti are Ugo Foscolo (1778–1827) and Ippolito Pindemonte (1754–1825), lesser poets but by no means unimportant.

Count Alessandro Manzoni (1785–1873) is the greatest Romantic novelist of Italian literature. As a religious man and reactionary, he is an antidote to the scepticism and liberalism of Monti and Foscolo. Manzoni wrote fine poetry, two remarkable tragedies, and a number of moralistic essays. But it was the novel *I Promessi Sposi* (The Betrothed) which established his fame (1825–27). The theme is simplicity itself: the love of Renzo and Lucia interwoven with the tragic story of a nun against a colourful 17th-century background.

From Blank Verse to Politics

Count Giacomo Leopardi (1798–1837) is the greatest Italian poet since Tasso ; as a lyricist he is supreme, and his blank verse is unequalled. He is also the master of a beautiful prose style, seen in his essays, dialogues, letters, and aphorisms. Contrast is provided by Giuseppe Giusti (1809–50). He excelled in satire, writing in an easy humorous style, usually in the Tuscan dialect. Gioacchino Belli (1791–1863) is somewhat obscure; he used the Roman dialect to depict the life of contemporary Rome in some 2,000 sonnets, each a lively miniature.

In drama Giovanni Battista Niccolini (1782–1861) is the outstanding figure. His tragedies are infused with a noble patriotism and idealism. *Arnaldo di Brescia*, his finest work, is a challenge to the papal power, poetic rather than dramatic ; it was never intended for the stage, and is overlong to be performed. *Antonio Foscarini* is the most successful of his other plays. Silvio Pellico (1788–1854) is remembered for one moving autobiographical volume, *Le Mie Prigioni*, and for his *Francesca da Rimini* ; and he wrote other plays.

During the same period Giuseppe Mazzini (1805–72) wrote on political subjects, as one would expect of this patriot; and also on the arts. Another political writer was the priest Vincenzo Gioberti (1801–52), a Platonic idealist who valiantly endeavoured to reconcile science and religion.

Advent of the Moderns

Most important as the forerunner of the modern school was Giosuè Carducci (1836–1907), in whom are the best qualities of Classicism and Romanticism combined—dignity and shapeliness invigorated by enthusiasm and original thought. He wrote noble poems and scholarly prose. Giovanni Pascoli (1855–1912), though uneven, rose to occasional greatness and was deservedly popular.

Among the novelists Antonio Fogazzaro (1842–1911) wrote with a sense of spiritual values, under the influence of Manzoni. *Piccolo mondo antico*, *Il Santo*, and *Daniele Cortis* are his most notable books. Better known is Giovanni Verga (1840–1922), the Sicilian novelist. The powerful *I Malavoglia* and *Maestro Don Gesualdo*, and several of his sketches and short stories, including *Cavalleria Rusticana*, were translated by D. H. Lawrence.

Matilde Serao (1856–1927) has been very popular ; *Il paese di Cuccagna*, *Il ventre di Napoli*, and *Fantasia* are her best novels, written in impressionistic style. Grazia Deledda (1875–1936) wrote vivid stories with a Sardinian background, notably *Il vecchio della montagna* (1900) and *Cenere* (1903).

In more recent Italian literature the picturesque figure of Gabriele d'Annunzio (1853 1938), Prince of Montenevoso, towers over all others. Brilliant alike in verse and prose, though it has been objected that he is wanting in the creative gift, d'Annunzio revivified Italian literature. His first volume of verse, *Primo Vere* (1879), appeared while he was a schoolboy and was highly praised. *Canto Nuovo* (1882) and *Terra Vergine* (1883) contained lyrics of intoxicating beauty and passion. In *Intermezzo di Rime* (1884) d'Annunzio showed a voluptuousness which some of his critics regarded as an unworthy influence. He invented the "rima nona," an Italian variant of the Spenserian stanza. It was, indeed, his instinct for formal beauty which, generally speaking, curbed the luxuriance of his imagination and saved him from mere extravagance.

Plays and Novels

He turned to play-writing in 1897, with a one-act fantasia. *La Città morta*, a tragedy in the classic manner, was written for Sarah Bernhardt, and *La Gioconda* (1898) for Eleanora Duse. His finest work, however, is in *Francesca da Rimini* (1902) and the rustic tragedy *La Figlia di Jorio* (1904). He wrote in French *Le Martyre de St. Sébastian* (1911), for which Debussy composed the music, and *Parisina* (1914), with music by Massenet.

D'Annunzio's novels had a somewhat wider public than his poems and plays. Starting in 1889 with *Il Piacero* (The Child of Pleasure), he made a sensation which was repeated with *L'Innocente* (known as The Intruder), *Giovanni Episcopo*, *Il Trionfo della Morte*, *Le Vergini delle Rocce*, and *Il Fuoco*. *Forse che si, forse che no* (1910) showed his interest in aviation. *La Nave* (1908) is non-fictional propaganda, urging Italy's development as a sea-power.

Less colourful but more influential outside his own country, Luigi Pirandello (1867–1936) was one of the world's most original dramatists. A Sicilian, he became a schoolmaster and wrote verse, short stories, and novels which had a restricted appeal. He began writing plays in 1912, with moderate success. It was not until 1921 that he achieved his reputation, with *Six Characters in Search of an Author*, which was translated into several languages and played all over the world. Best known of his other plays are *Henry IV* and *As You Desire Me*. He also wrote one-act dramas; *The Man With a Flower in his Mouth* is most poignant. In 1925 he founded his own theatre in Rome, and took his plays on tour in Europe. Their success created a public for his novels, of which *The Outcast*, *One, None and Ten Thousand*, and *The Naked Truth* should be noted. Of his short stories, a selection is available in English translation, in a volume entitled *Better Think Twice About It*. In 1934 Pirandello was awarded the Nobel prize for literature.

Modern poetry has been influenced by Filippo Marinetti (1878–1944), who founded Futurism in 1909. The far-reaching influence of Benedetto Croce (1866–1952) has been an important factor in modern thought. Certain it is that he stands head and shoulders above his contemporaries in the interpretation of history, in criticism, and in philosophy. His *Aesthetic* is a fundamental work, expounding his famous theory that all art is akin to lyrical intuition. This work and that of Giovanni Gentile (1875 1944) are two of the highest peaks in the philosophy of interpretation. Gentile's particular contribution is his *Theory of the Mind as Pure Art*. Like Croce, he was influenced by Hegel. The Fascist revolution dried up the springs of literary inspiration, and the new inspiration has not yet had time to make its mark.

LESSON 10

German—I: Early, Classical, and Middle Period

GERMAN literature goes back to a period of Old High German which began in the 8th century and ended in the 11th. Then came the Middle High German (or Medieval) period lasting until the 16th century, followed by the Modern High German period, which may be subdivided into an early period, sometimes called the German Renaissance, lasting up to the end of the 17th century, the Classical period, occupying the 18th century, the Romantic period of the early 19th century, and the late period. From the Old High German period, only a small amount of religious literature and some fragmentary lays remain.

The Middle period saw the rise of the *Spielmann*, or wandering singer, through whom a secular literature came into being. This literature took three main forms: the national (or popular) epic, the court epic, and the lyric, or *Minnesang*. At first the influence of French literature was strong; the first purely German popular epic was *König Rother* (*c.* 1160), which, like much of contemporary literature throughout Europe, introduced scenes from the Orient, inspired by the Crusades.

Among the world's greatest epics is the *Nibelungenlied* (Lay of the Nibelungs), which dates from the end of the 11th century. The story, based on various sagas which deal with the hero Siegfried, has become familiar through

Wagner's *Ring* cycle. Complementary to the *Nibelungenlied* is the epic of *Gudrun*, and there is also a group known as the *Heldenbuch*, based on old sagas which had Dietrich (Theodoric the Goth) as hero. The court epic, similar to the French "roman courtois," centred upon the Arthurian legends. Hartmann von der Aue, Wolfram von Eschenbach, and Gottfried von Strassburg were the most important poets. Hartmann, under the influence of Chrétien de Troyes, wrote *Der arme Heinrich* and *Iwein*, fresh and shapely romances. Wolfram, author of *Parzival* (about 25,000 lines), is the greatest of medieval German poets and the greatest European poet before Dante. Gottfried's *Tristan* is another masterpiece of medieval literature.

The Minnesang

The Minnesang was derived from the Provençal lyric in form and content. Notable among the minnesingers was Walther von der Vogelweide (*c.* 1170–*c.* 1228). His *Unter den Linden* is among the treasures of medieval Germany. Later, the courtly minnesingers were replaced by the "meistersingers," who learned their art in schools, according to formula. In another vein, the most famous satire of its period, the *Narrenschiff* of Sebastian Brandt (1458–1521), appeared in 1494.

In prose, the Schwank, or humorous anecdote, was most popular; sometimes a number of these were collected round a central figure, as in *Tyl Eulenspiegel* (1515). Beast fables were common; *Reinke de Vos*, a version of the *Roman de Renart*, appeared in 1498.

Religious Writings

Mysticism in Germany began with Meister Eckhardt (*c.* 1260–*c.* 1327). Its essence was an intensely personal communion with God, and it therefore contributed to the Protestant Reformation in requiring that the Bible should be made accessible in the mother-tongue. The first translation from the Vulgate into German was published in 1466. Germany's greatest man at this period was Martin Luther (1483–1546). Luther wrote the most important of the polemical treatises on the Protestant side. The Catholic side had a doughty champion in the Franciscan scholar Thomas Murner (1475–1537), most brutal of satirists.

Drama flourished during the latter part of the Medieval period, manifesting itself chiefly as scholastic comedy based on Latin models and as the *Fastnachtsspiel*, or Shrovetide play, a brief episode with a moral lesson, often treated humorously. Hans Sachs (1494–1576), a cobbler of Nuremberg, had a considerable output of verse and drama, and was especially happy in his Shrovetide plays.

There was a recrudescence of mysticism in the philosophy of Jakob Böhme (1575–1624), whose influence is seen in the poet Johann Scheffler (1624–77) and later in the English William Blake. The Jesuit Friedrich von Spee (1591–1635) and the Lutheran Paul Gerhardt (1607–76) were among those who contributed most to the religious poetry which is the glory of the 17th century—the German Renaissance. A most important contemporary figure was Martin Opitz (1597–1639), whose *Buch von der deutschen Poeterey* (1624) formalised German poetry as Boileau was later to formalise the poetry of France.

Spanish Influence

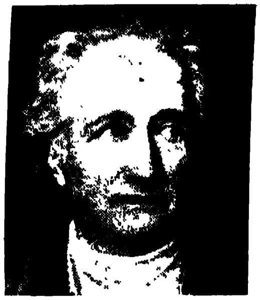
The novel had originated in the 15th-century Volksbuch, of which the *Historie von D. Johannen Fausten* is the most interesting example. In the 17th century Spanish influence was supreme. The first of the Spanish picaresque novels, *Lazarillo de Tormes*, was translated in 1617, and *Don Quixote* in 1625. The greatest German novel of the century is *Der abenteuerliche Simplicissimus*, by Hans Jakob Christoffel von Grimmelshausen (*c.* 1624–76). The critic Johann Christoph Gottsched (1700–66) tried to impose the standards of the French classicists, but English naturalism triumphed and brought the German Renaissance belatedly to its close. The first great German philosopher, Gottfried Wilhelm Leibnitz (1646–1716), contributed much to the growth of rationalism, which was one of the characteristics of the Classical age; but he wrote mostly in French and Latin. Friedrich Gottlieb Klopstock (1724–1803) was the first great poet of modern German literature. His vast religious work *Der Messias*, inspired by Milton's *Paradise Lost*, appeared in parts (1748–73); on this his immediate reputation was founded. He was also a notable dramatist: three of his plays, influenced by the translation of Macpherson's *Ossian*, glorify the early patriot Hermann.

Klopstock was followed by Christoph Martin Wieland (1733–1813), poet, playwright, and novelist, whose *Agathon* (1767) was the first modern German novel; written under the influence of Richardson, it shows the hero's psychological development against a classic background. Wieland's best-known work is the epic *Oberon* (1780), a rendering of the old French romance *Huon de Bordeaux*, with additions from Chaucer and Shakespeare.

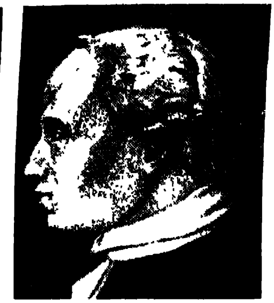
Gotthold Ephraim Lessing (1729–81) will always be remembered for his unfinished critical essay *Laokoon* (1766), an attempt to define the spheres of poetry and the plastic arts. Of his plays, *Minna von Barnhelm* (1763) was the first really great comedy in the German language.

Gottfried Herder (1744–1803), a profound thinker, had one of the most original minds of his day. In 1773 he wrote, as the manifesto


Lessing


Goethe


Schiller


Kant

of the "Sturm und Drang" (storm and stress) movement, directly influenced by Rousseau, *Von deutschen Art und Kunst*. This movement was preluded by the Gottinger Dichterbund, a group of poets of whom Gottfried August Bürger, the famous ballad writer (1747–94), was the chief. Bürger's *Lenore* became known throughout Europe.

Goethe

The great figure of his age was Johann Wolfgang von Goethe (1749–1832). Outside Germany, Goethe's reputation rests chiefly on his tremendous drama *Faust* (first part, 1808; second, 1832). His works embrace almost every form of literature: essays, novels, poetry, history, drama, criticism. His genius was first revealed in lyric poetry; the *Sesenheimer Lieder* and the impassioned *Wanderers Sturmlied* are deeply emotional masterpieces. Then came a play influenced by Shakespeare – *Götz von Berlinchingen* (1773), and the novel *Werthers Leiden*, known in English as *The Sorrows of Werther* (1774), which became popular throughout Europe. In Italy Goethe wrote *Iphigenie auf Tauris* (1787), a superb adaptation of Euripides, which, with *Egmont* (1788) and *Torquato Tasso* (1790), makes up a trio of great dramas. *Wilhelm Meisters Lehrjahre* (1795–96) is a novel of serious purpose, showing how a romantically-minded young man learned to adapt himself to life. Years later Goethe continued it in *Wilhelm Meisters Wanderjahre* (1821–29). Of his other works, *Hermann und Dorothea* (1798), a narrative poem in hexameters, has a simple perfection, and the novel *Die Wahlverwandtschaften* (1809) is a psychological study in the classical manner.

Schiller and Kant

Second only to Goethe in importance is Johann C. Friedrich von Schiller (1759–1805), whose first play, *Die Räuber* (1781), a moving tragedy, embodies the spirit of "Sturm und Drang." By 1782 he had also established himself as an outstanding lyric poet. He excelled in philosophic lyrics and in ballads; the glorious *Lied von der Glocke* (1799) is his highest achievement in poetry. Of Schiller's many plays, *Kabale und Liebe* (1784) was the first great tragedy of love in German drama, and *Don Carlos* (1787) was a striking plea for freedom of thought. Schiller's dramatic masterpieces, however, are the *Wallenstein* trilogy, *Maria Stuart*, *Die Jungfrau von Orleans*, *Die Braut von Messina* (written in the manner of Greek tragedy), and *Wilhelm Tell*; these represent his later work, from 1798 onwards.

As a critic Schiller is most interesting in his *Über naive und sentimentalische Dichtung* (1795–96), in which he divided literature into two groups – the "naive," such as is found in natural poetry and in the work of great geniuses like Shakespeare, and the "sentimental," which does not create but gives shape to things already in existence.

The greatest philosopher since Descartes, Immanuel Kant (1724–1804) was a rationalist who taught submission to the moral law. The *Kritik der reinen Vernunft* (Critique of Pure Reason) is his best-known treatise (1781). Johann Gottlieb Fichte (1762–1814) was his most important disciple; and Friedrich von Schelling (1775–1854) expressed the metaphysical doctrines of Romanticism.

The German Romantics

One of the earliest Romantics was Friedrich Holderlin (1770–1843), a gifted lyric poet who found his inspiration in ancient Greece. Hölderlin, a passionate idealist, wrote splendid, though obscure, odes and hymns which have affinities with the *Prophetic Books* of William Blake; *Patmos* is outstanding among them. His novel *Hyperion* is also noteworthy.

In 1798 a little group of romantic writers was formed, its chief members being Friedrich von Hardenberg (1772–1801), who wrote as "Novalis," Ludwig Tieck (1773–1853), W. H. Wackenroder (1773–98), August Wilhelm Schlegel (1767–1845), and his brother Friedrich (1772–1829).

Novalis was a mystic whose genius finds

supreme expression in his *Hymnen an die Nacht*, the rhapsodic prose of *Die Lehrlinge zu Sais*, and the faery romance *Heinrich von Ofterdingen*. Tieck wrote romantic dramas which are poetic rather than dramatic ; he was influenced by Calderón. He was also a novelist ; the early *William Lovell* is Wertherish, *Franz Sternbald* (1798) and *Der junge Tischlermeister* (1836) are in the *Wilhelm Meister* spirit, and *Der Aufruhr in den Cevennen* (1826) is an excellent historical novel, showing that influence of Scott which was prevalent throughout Europe at this time. Tieck's *Novellen* (short stories) and *Märchen* (fairy tales) should also be remembered. Wackenroder, who was Tieck's friend, wrote a stimulating little book on the arts. The Schlegels had a European reputation as critics, and produced volumes of essays. August began the translation of Shakespeare ; he also translated Calderón.

The Heidelberg Group

A second Romantic school, known as the Heidelberg group, was founded by Klemens Maria Brentano (1778 1842), Ludwig Achim von Arnim (1781 1831), and J. J. von Görres (1776-1848), with whom the Grimm brothers, Jakob (1785 1863) and Wilhelm (1786-1859), were associated. Brentano and Arnim made an excellent collection of German Volkslieder in *Der Knaben Wunderhorn* (1805-8) ; its effect is seen in lyric poetry throughout the century. The Grimms, world-famous for their *Märchen*, were scholarly philologists. Brentano wrote the allegory *Romanzen von Rosencranz* (1852). Arnim developed as a historical novelist. They were now associated with Adelbert von Chamisso (1781-1838), who came of an exiled French aristocratic family and was one of the most delightful lyric poets writing in German. Chamisso was author, too, of the popular *Peter Schlemihls wundersame Geschichte* (1814), the fantastic story of the man who lost his shadow.

Other Notable Romantics

Other notable Romantics were Baron Joseph von Eichendorff (1788 1857), a lyric poet with a true love of nature, who was also a novelist, author of *Aus dem Leben eines Taugenichts* (translated as *Memoirs of a Good-for-Nothing*) ; Ludwig Uhland (1787 1862), famous as a ballad-writer in the true Volkslied tradition ; the Austrian Nicolaus von Strehlenau, or Lenau (1802-50), a superb though pessimistic lyric poet ; Friedrich Rückert (1788-1866), a consummate artist, who drew his inspiration from Oriental studies ; Wilhelm Müller (1794-1827), one of the champions of Greek independence, who wrote a surprising amount of lovely and sincere verse ; the Swabian Eduard Mörike (1804-75), whose lyrics have a restraint and simplicity which sets them apart ; and Annette von Dröste-Hülshoff (1797-1848), who wrote an epic of the Thirty Years War, besides nature poetry and religious poetry of real insight.

Chief Figures in Drama

In drama the chief figures were Zacharias Werner (1768-1823), whose somewhat turgid plays combine historic and religious interest ; Heinrich von Kleist (1777 1811), a great dramatic poet who was also a novelist ; and Franz Grillparzer (1791-1872), an Austrian, some of whose masterpieces are based on themes from the Greek classics or from German history. Karl Immermann (1796-1840) experimented in kinds of drama and poetry ; his most memorable work is the dramatic poem *Merlin*. Linked with drama, one must remember the opera, in which at this time are the illustrious names of Gluck, Mozart, Beethoven (" Fidelio "), Weber, Meyerbeer, and Wagner.

The Romantic Novel

Of Romantic novelists, Ernst Theodor Wilhelm Hoffmann (1776-1822) is outstanding. In *Die Eliziere des Teufels*, *Phantasiestücke*, *Nachtstucke*, and *Klein Zaches*, he revived the tale of terror which Monk Lewis had begun in England ; he also wrote stories of a more normal kind, such as *Das Fräulein von Scuderi* and the humorous *Kater Marr*. Friedrich de la Motte Fouqué (1777 1843) was a popular but commonplace writer who lives by virtue of two charming fairy stories, *Undine* and *Sintram*. Immermann wrote *Die Epigonen* (1836), foreshadowing the novel of social purpose, and *Münchhausen* (1838-9) ; this last contains an excellent short story of peasant life, *Der Oberhof*, the first specimen of the peasant literature which was afterwards developed by the Swiss pastor, Albert Blizius, writing as " Jeremias Gotthelf " (1797-1854), by Berthold Auerbach (1812-82) and Adelbert Stifter (1805-68), and by Peter Rosegger (1843-1918).

Historical Novels

The historical novel had already won popularity, which the Waverley Novels increased to a furore. Wilhelm Hauff, W. H. Häring (" Willibald Alexis "), Karl Spindler, and Heinrich Zschokke wrote in the Scott tradition, which Alexis afterwards outgrew. Later, Gustav Freytag (1816 95) dealt with successive epochs of German history and also wrote novels of social purpose, and plays. Georg Ebers and Felix Dahns took their themes from antiquity.

LESSON 2

German—II: Modern Period

Heinrich Heine

Hegel

Schopenhauer

Nietzsche

THE central figure of the Young Germany movement was Heinrich Heine (1797–1856), a Jew of working-class family. One of the sweetest singers in all literature, Heine won instant fame with *Buch der Lieder* (1827), which contains some of his loveliest lyrics; *Die Lorelei*, *Die Grenadiere*, and *Du bist wie eine Blume* (Thou art like a flower) are unsurpassed. He produced several other volumes, of which *Die Nordsee* is a cycle of sea poetry, *Atta Troll* is an enchanting tale with an allegorical meaning, and the *Romanzero* contains his mature verse, noble and sincere. Heine also wrote excellent prose, of which a selection has been translated into English by Hermann Kesten (1943).

Philosophy

Of the German philosophers Georg Wilhelm Friedrich Hegel (1770–1831) is most important, but he wrote obscurely. The deep pessimism of Arthur Schopenhauer (1788–1860) is reflected in Romantic poetry, and his excellent prose style gives added importance to *Die Welt als Wille und Vorstellung* (1819) and to his essays *Parerga und Paralipomena*.

Extremely influential was Friedrich Nietzsche (1844–1900), who laid down the doctrine of individualism, carried to the point where the Superman should be dominant. Nietzsche wrote voluminously and was an artist in prose. His outstanding work, *Also sprach Zarathustra* (1883–91), is the most important contribution to German literature at this period.

Post-Romantic Novels

Among the chief novelists in the latter part of the century was Gottfried Keller (1819–90), author of *Der grüne Heinrich*, which was the last great Romantic novel in the tradition of *Wilhelm Meister*: he was also a masterly short-story writer, as were Theodor Storm (1817–88), W. H. Riehl (1823–97), Konrad Ferdinand Meyer (1825–96), and Paul Heyse (1830–1914). Heyse wrote several novels, his *Kinder der Welt* (1873) being most noteworthy. Karl Gutzkow (1811–78), leader of the Young Germany movement, is best remembered for *Der Ritter von Geiste* (1850–2), a social novel which attempts to represent a whole epoch. Friedrich Spielhagen (1829–1911) was excellent in this genre. Fritz Reuter (1810–74) was the most important of the provincial writers, using the "Platdeutsch" dialect of Mecklenburg in his great novels, which have been compared with the work of Dickens. Theodor Fontane (1819–98) was the most influential of the realists.

In drama Christian Friedrich Hebbel (1813–63) was the first to write plays of psychological interest, forerunners of the work of Ibsen. Otto Ludwig (1813–65) was a realist, and excelled in novel-writing as well as in plays. Ludwig Anzengrüber (1839–89) chose his themes from peasant life in Austria.

Dramatists

Gerhart Hauptmann (1862–1946) began his career as dramatist in the late eighties, at first under the influence of Zola and later under that of Ibsen. He wrote a series of plays on pathological subjects, had his first success with the realistic *Die Weber* (1892), and went on to psychological plays and fantasy, besides comedy. By 1914 Hauptmann dominated the German stage. His only rival was Hermann Sudermann (1857–1928), who had begun a new era of realism with *Die Ehre* (1889). Sudermann is best known in England for *Die hohe Lied* (Song of Songs, 1908). These two writers were fine novelists. There were other talented dramatists, including Frank Wedekind (1864–1918). In Austria, drama was worthily represented by the Viennese Jew, Arthur Schnitzler

(1862–1931), famous for his one-act plays and for *Professor Bernhardi*, and by the half-Jewish Hugo von Hofmannsthal (1874–1929), who wrote lyric drama.

German lyrical poetry in the modern period shows variety and originality. Most important at the turn of the century were Freiherr Detlov von Liliencron (1844–1909) and Richard Dehmel (1863–1920). Liliencron was an innovator in diction ; he had a lively impressionistic style. Dehmel, a dynamic figure, was influenced by the French Symbolists, but retained a passionate individuality ; he was also an excellent translator of Villon and Verlaine and of Chinese poetry.

Stefan George (1868–1933) produced much work of great beauty and austere power, influenced by Malarmé ; he was also responsible for translations of Shakespeare's sonnets, and of Dante, Baudelaire, and the Symbolists. His patriotic verse earned Nazi appreciation. The beautiful writing of Albert Mombert (1872–1942) and Theodor Däubler (1876–1934) and the colourful poems of Max Dauthendey (1867–1918) are impressionistic, in strong contrast with the group of working-class poets, who included Karl Bröger (b. 1886) and Gerrit Engelke (1898–1918).

The Works of Rilke

Rainer Maria Rilke (1875–1926), who was born in Prague, is now recognized as Germany's greatest modern lyric poet, remarkable for subtlety of thought and for originality of form. Of his exquisite poetry the first notable expression is in *Die Weisse Fürstin* (The White Princess, 1899, revised in 1904), an eerie poetic drama in the manner of Maeterlinck. More important achievements are *Das Stundenbuch* (The Book of Hours, 1905), a rhapsodic cycle ; *Neue Gedichte* (New Poems, 1907–8), in which scenes and objects encountered on his travels stimulate the poet to re-create the past with which they were associated ; the superb *Fünf Gesänge* (Five Hymns, 1914), under the influence of Hölderlin, which marked the outbreak of war ; the *Duineser Elegien* (Duino Elegies, 1923), a lurid apocalyptic vision of life, written while he was the guest of Princess Marie Thurn at her Castle of Duino on the Adriatic ; and the magical *Sonette an Orpheus* (Sonnets to Orpheus, 1922), metaphysical, even mystical, in content. Rilke also wrote a remarkable Werther-ish novel, *Malte Laurids Brigge*, which has been described as " a great symphony of fear." Among the decadents were Georg Heym (1887–1912) and Georg Trahl (1887–1914) ; and Gottfried Benn (b. 1886), a Berlin surgeon, is starkly realistic.

Impressionism and Expressionism

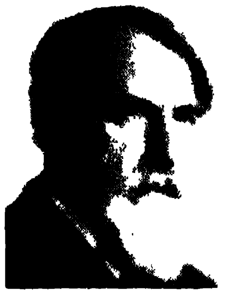
The impressionistic novel, a development from Zolaesque naturalism, is exemplified in the work of Emil Strauss, Hermann Hesse, who was awarded a Nobel prize in 1946, Hermann Stehr (1864–1940), Jakob Wassermann (1873–1934), Heinrich Mann (1871–1950), and his brother Thomas Mann (1875–1955). The last named, in his monumental symbolic work, *Die Zauberberg* (The Magic Mountain, 1924), used psycho-analysis to indicate the moral degradation of the period just before the First World War in Germany.

The leading expressionists in fiction were Rene Schikele (1883–1940), Franz Kafka (1883–1924), Leonhard Frank, Kasimir Edschmidt, Alfred Döblin, and Franz Werfel (1890–1945), world-famous for *The Song of Bernadette*. Döblin's *Berlin Alexanderplatz*, and the *Perrudja* of Hanns Henny Jahnn, are the first German novels in the manner of Joyce's *Ulysses*, both appearing in 1929. Werfel was also a poet and dramatist, author of the symbolic trilogy, *Der Spiegelmanch*. Vicki Baum (b. 1888) published *Menschen im Hotel* (Grand Hotel, 1929) and other novels in the expressionist manner.

Expressionistic drama found its chief exponents in Georg Kaiser (1878–1945) and Ernst Toller (1893–1939), who were Communists. Kaiser's best known plays are *Die Bürger von Calais* (1914), *Von Morgens bis Mitternachs* (From Morn to Midnight, 1916), and *Gas* (1918–20). The works of Toller, a

Gerhart Hauptmann

Hermann Sudermann



Arthur Schnitzler

Rainer Maria Rilke

political refugee from 1933, have been widely translated, His best-known plays are *Masse-Mensch* (Masses and Men, 1921) and *Die Maschinenstürmer* (The Machine Wreckers, 1922). Violence and abnormality give a distorted effect to the work of such expressionists as Arnolt Bronnen and Oskar Kokoschka.

Other Aspects

The historical novel has continued to be important, in its modern form. Guido Kolbenheyer, a mystic, is at his best in a trilogy on Paracelsus. Ricarda Huch, without doubt Germany's foremost woman writer, brought to historical fiction a breath of vision, a psychological insight, and a lyric style which turn her studies of Italian history and of the Thirty Years' War into prose epics. She also wrote excellent social novels, short stories, and lyrics. Stefan Zweig (1881–1943) wrote the cinematographic *Marie Antoinette* (1932), which made a successful film; he was a lively biographer. Alfred Nuemann wrote the exciting *Der Teufel* (1926) and *Konigin Christina von Schweden. Jud Süss* (Jew Suss) by Lion Feuchtwanger became a best-seller. Emil Ludwig (1881 1948) wrote successful novels and plays, but after his *Goethe* (1920) he devoted himself mainly to biography.

The First World War produced another world-famous novel, *Im Westen Nichts Neues* (All Quiet on the Western Front, 1929), and its sequel, *Der Weg zuruck* (The Way Back), by Erich Maria Remarque. A more lasting reputation was won by *Der Streit um den Sergeanten Grischa* (1926–7), by Arnold Zweig.

English readers are familiar with the delightful child-stories of Erich Kästner (b. 1899), author of *Emil und die Detektive*, and with Hans Fallada's (1893–1947) poignant *Little Man, What Now?*

Of the thinkers, Oswald Spengler (1880 1936) propounded the decay of Western civilization and the coming of dictatorships in his *Der Untergang des Abendlands* (The Decline of the West), much of which he afterwards recanted.

Mein Kampf

The year 1924 saw the appearance of that strange book, *Mein Kampf*, written by the Austrian Adolf Hitler (1889–1945). To a Germany that was still in despair after military defeat, and struggling to find a new soul, Hitler promised recovery and power through National Socialism. Never in history has so incoherent and ill-written a work produced such effects. It touched the predatory and warlike instincts of the nation, and reanimated its desire for revenge and domination. It was supplemented by Alfred Rosenberg (1893–1946), who in *The Myth of the 20th Century* provided the elaborated reasoning lacking in Hitler's elemental and elementary work.

The Nazis immediately began a liquidation of all writing which did not suit their fanatical creed. The burning of the books began. It is thus described in an official publication:

> The fire of the pyres which flared up in German lands in May 1933, is to us a sign and a symbol of an inflexible will to purity.

The Prussian Academy of Arts was purged of men of liberal, humanitarian, or democratic tendencies, and, of course, of all Jews. It was renamed the German Academy of Literature, and Stefan George was asked, but refused, to become president in place of Heinrich Mann, who had left Germany. A decree of September 22, 1933, set up a very strict control of all the arts under Dr. Goebbels (who had himself failed as a writer). A list of forbidden books and authors was issued; it included Heinrich Heine, because he was a Jew. It is interesting to compare this with what had happened in the U.S.S.R. after the Russian Revolution. In Russia literature recovered and began to flourish; in Germany it all but died. Of the established writers Stefan George remained somewhat apart from the new order; Gerhart Hauptmann, Ernst Wiechert, Ernst Junger, Ernst Bertram, Rudolf G. Binding, Ina Seidel, and Agnes Miegel continued to find favour. Erwin Guido Holbenheyer became popular.

The "Blubo" School

The younger generation produced work of the true Nazi tone and ideology. One of their theorists, Walther Darré, took the motto "Blut und Boden" (Blood and Soil), and from it sprang the "Blubo" school of writers, who emphasised the importance of (German) blood and (German) soil. Friedrich Griese (b. 1890) and Ernst Wiechert (b. 1887) were leading exponents of the "Blubo" novel. Expansionist dream-fantasies of Nordic supremacy and world power entered into novels, short stories, verse, and plays. Histories were rewritten to accord with the new credo.

It is to the emigré writers' works that one must look for the best that was produced between 1933 and the end of the Second World War. This includes the *Behemoth* of Franz Neumann, a profound study of the new Germany and the Nazi creed.

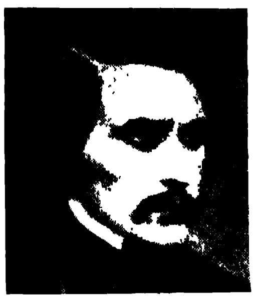
Briefly surveying German literature of the post-war period, we may cite Anna Seghers and Johannes Becher as two writers who represent the East Germany school of Marxist writers. In Western Germany the neo-expressionist writer Gottfried Benn leads new writing. Holthusen is a new Rilke, R. A. Schröder continues the Protestant Christian tradition, and Ernst Jünger's prose presents a new Stefan George. Roman Catholic writers wield increasing influence.

LESSON 9

Russian Imperial Literature

RUSSIAN writing of the 10th to the 15th centuries holds the essential material on which to base estimates of Russian character and psychology, with their various conflicting elements—Mongol, Tartar, Germanic, and Slav. There are few masterpieces in old Russian literature. One work deserving mention is *The Campaign of Igor* (*c.* 1186). It stands almost alone in that it is native, secular (as contrasted with a mass of ecclesiastical) poetry in narrative form. Not only is this a work of literary art, but it is a source book for contemporary customs, problems, and outlook. Between the famous *Igor* and the remarkable *Autobiography* of the Archpriest Avvakum (1620–81) there is no very definite line of development.

Alexander Pushkin



Nikolai V. Gogol

Formative Elements

The Russian language developed continuously and progressively; this still goes on in our own times. Highly flexible and subtle, it is capable of tremendous energy and power, great elegance and sonority, while it covers the whole range of melody, delicacy, refinement, and the picturesque. Its extraordinary ability to embody in one word a set of ideas or a whole figure, together with a wonderful variability of the tonic accent, render it capable of almost every imaginable rhythmic combination, and make it the ideal language for the poet and for what is more common with the Russians than with us, the writer of poetic prose.

An important element was the development of an intensely realistic outlook, with which went the elimination of any tendency to abstraction and the metaphysical or sentimental spirit. The complete absence of sentimentalism in Russian literature often strikes the English reader as a little too brutally positive. In some writers, the realism goes so far as to bring scepticism and irony to the point of melancholy, and even to that curious and essentially Russian mysticism which Dostoyevsky was to show to a remarkable degree in a later age. These two elements—the language and the realistic outlook—both traceable from the earliest times, make Russian literature what it is.

The originality of the Russians lies not in the creation of new forms but in an intense application of individual genius combined with creative forces outside the field of literature. The Russians were content to accept well-tried forms from outside sources: especially from the Italian Renaissance and from the French, but also from the Germans and the Poles. Modern Russian literature is usually dated from the 17th–18th century. Mikhail Vasilievich Lomonosov (1711–65) followed the French classical tradition; Karamzin (1765–1826) and Zhukoiski (1783–1852) were popularisers, with their essays and translations. Ivan Andreievich Krylov (1768–1844) was the great fabulist; he began his reputation by translating the work of La Fontaine.

Pushkin

For many, the supreme name in Russian literature is that of Pushkin (1799–1837). Alexander Sergievich Pushkin read widely, listened carefully to his elders, began to write critical essays and verse, and decided he would make writing his life's occupation. At the age of 19 he caused deep interest among his friends with his romance *Russlan and Ludmila*. His outstanding works are *The Captain's Daughter* and his inimitable short stories, such as *The Queen of Spades*. Great as his prose works are, his poetry is that by which he will be remembered. His principal work is *Eugeni Onegin*, a novel in verse; his great tragedy was *Boris Godounov*. The essential humanity of his writings gives Pushkin a universal appeal which is as strong to-day as when he wrote. Pushkin had a worthy successor in Mikhail Yurevich Lermontov (1814–41), master of lyric and dramatic poetry, mostly inspired by the legendary beauty of the Caucasus. *The Demon* has been translated into English, as has his novel *The Hero of Our Times*.

Gogol

Of this period, too, is Nikolai Vasilievich Gogol (1809–52), whose satirical epic *Dead Souls*, written in a prose that is ornate and elaborate, was to be the foundation of the realistic novel in Russia. It is a humorous, picaresque novel and at the same time a social

satire with political implications. In *Dead Souls*, while ostensibly chronicling the adventures of a rascal and vagabond, Gogol gives a very realistic survey of actual conditions among the serfs, in which there is behind the façade of the comic and hearty a deep sadness and pity. Gogol is also famous for plays, the most popular being *Revisor* (i.e. Inspector, published in English as *The Government Inspector*) ; and for *Taras Bulba*, an epic tale of the Cossacks. He wrote other works that are too essentially Russian to be translated.

The Great Age

From the publication of Pushkin's first work in 1820 to the Revolution of 1917—roughly one hundred years—is considered to be the great age of Russian literature. It was an age in which the novel dominated both poetry and drama excepting always Pushkin's work. Nikolai Alexeivich Nekrasov (1821–77) was the most important radical, or " left wing," writer and editor of the middle period of the century. Adored by the people and the revolutionary intelligentsia, he was detested by the aristocracy and officialdom. His review *Sovremennik* (The Contemporary), although mainly radical, attracted all the best writers. It was in it that he first began to publish his own verse ; and on it his fame rests. Nekrasov's influence on political thought is not forgotten to-day in the U.S.S.R., but that alone would not have won for him the sure place he has in the national literature. His poetry is vigorous and realistic, with astonishing verbal felicity. Of all his work, it is largely due to *The Pedlars* and *Who Can be Happy and Free in Russia ?* that Nekrasov stands head and shoulders above his contemporaries. He remains the giant of the satirical epic. There is a good translation of *Who Can Be Happy*, and also of another fine poem, *The Red-Nosed Frost*.

Outstanding Poetry, Drama, and Prose

Alexander Nicolaevich Ostrovski (1823–86) is the outstanding dramatist of his period. He did not so much create characters as write for " character actors," for his people are presented as types rather than as analysed individuals. Few dramatists excel him in his own field. His plays, like most Russian plays, are undramatic by English standards and they are not much concerned with plot, though they are admirably constructed for acting. His greatest work—and it is one of the masterpieces of Russian literature—is *The Thunderstorm*. This is a piece of dramatic poetry which alone would place him among the immortals. It was translated by Constance Garnett in 1899.

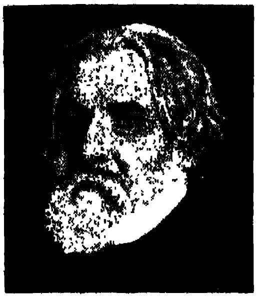
While Nekrasov and Ostrovski exemplify the best in poetry and drama, it is to the prose writers that one turns for the really great literature of the 19th century. Ivan Sergievich Turgenev (1818–83) had the good fortune when a student to make the acquaintance of a Professor Pletnev who was an intimate friend and worshipper of Pushkin, and from Pletnev he imbibed an enthusiasm to follow the classical tradition. Like Pushkin, he began as a poet but, in spite of the appreciation of the critics, abandoned poetry for prose and would never allow his early efforts to be republished. In 1846 appeared his *Sportsman's Sketches* as a serial which attracted little attention ; when it came out in book form it brought him immediate fame. There could be no doubt in any reader's mind but that here was a great writer. One of the sketches, called *The Bezhin Meadow*, is a prose-poem so perfect in style and form that it is an established masterpiece of the language.

When Gogol died, Turgenev wrote a glowing appreciation in terms which displeased the authorities and cost him a month in prison and eighteen months' banishment. After it sketches, short stories, essays, and novels came quickly from his pen. The most famous are *A House of Gentlefolk* (1858), *On the Eve* (1860), *Fathers and Sons* (1862), which excited controversy ; and, after he had left Russia and made his home in Baden, *Smoke* (1867) and *Virgin Soil* (1877). His short stories include *Aysa*, *First Love*, *A Lear of the Steppes*, and *Torrents of Spring*. He wrote an excellent play, *A Month in the Country*, which has achieved popularity in Britain. Turgenev has a pure, straightforward style, and his work is appreciable in translation.

The Genius of Dostoyevsky

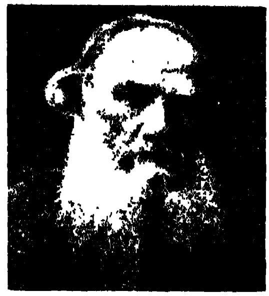
Of that strange, uncanny genius Feodor Mikhailovich Dostoyevsky (1821–81), it can be said that his chief works belong to all literature and to all time. Unlike his predecessor Turgenev and his contemporary Tolstoy, Dostoyevsky, though not a plebeian, had financial difficulties. At the university he took a brilliant degree in engineering. He entered the army with a commission, but left it after three years to devote his life to literature. His faith was a humanitarian socialism, and when his first novel, *Poor Folk*, appeared in 1845, Belinski and Nekrasov acclaimed it and announced that a " new Gogol " had arrived.

His next book, *The Double*, baffled and bewildered the critics, some of whom received it with derision. It deals with border-line insanity, and reached a profundity of subtle analysis and psychological insight hitherto unknown. Suddenly this highly sensitive man of genius had a dreadful experience. His extreme revolutionary views caused his arrest and trial and resulted in a sentence of death. With some others he was led to a square, half-stripped, in mid-winter, to be executed—a scaffold and hangman ready, a cart with coffins near by. He could not



Ivan Turgenev

Feodor Dostoyevsky



Leo Tolstoy

Anton Chekov

understand it at all. "Is it possible that we are going to be executed ?" he asked of a fellow-prisoner. At the very last moment they were reprieved. One of them lost his reason completely. Dostoyevsky, an epileptic, was sent to Siberia for four years' imprisonment, after which came three years' army service.

Dostoyevsky returned stronger morally and more balanced in mind than ever before. *Memoirs of the House of Death*, a work of extreme realism, was the first fruit of his imprisonment, to be followed by an intensively creative period in which novel quickly succeeded novel—*Crime and Punishment*, *The Idiot*, and *The Possessed*, to mention only three, each a masterpiece—until in 1880, the year before he died, was published *The Brothers Karamazov*. In all his books Dostoyevsky is intensely preoccupied with the Russian soul. He emphasised again and again that the strength of Russia lies in her faith in man and the rejection of superstitions which would impair that faith. Apart from this, Dostoyevsky's place in world literature is secure. As a background to all his work there is a humanitarian, socialistic philosophy to which is added a finely detailed knowledge of human nature and mental processes drawn chiefly from his own experiences and his close observation of his fellow-men.

Tolstoy

One towering genius such as Dostoyevsky would suffice for an age, yet contemporary with him was Count Leo Nikolaevich Tolstoy (1828 1910), a landed aristocrat who became a man of letters and social reformer, of literary rank equal to Dostoyevsky's. From the time when he first he began to write, Tolstoy showed a remarkable faculty for imparting to all his work the air of absolute truth. In all of it one finds a fidelity which causes the reader to say "*This* is not fiction ; it is *life* !" Tolstoy's output was considerable—essays, criticism, philosophy, religion, tales, sketches, educational works, drama, and novels. Much of it is now in oblivion, but the world reads with admiration his two finest novels *Anna Karenina* and *War and Peace*.

Tolstoy's characters have the actuality of flesh and blood, with passions, virtues, and failings that he records with unequalled verisimilitude. These two books are "slices of life" in the truest sense. No writer is a more exact observer ; none can use words better to convey truth ; and none is more of a fanatic for the truth. It is this quality which makes Tolstoy a giant. To the Russians his name is one of the greatest.

Philosophic Fathers of the Revolution

The last half of the 19th century produced in Russia writers who were the philosophic fathers of the Revolution. While their works may be important politically, only one deserves to be included in a survey of literature, and that is Prince Peter Alexeivich Kropotkin (1842–1921), a man of science and letters and the leader of a school of anarchist thought of which he is the philosopher. Earlier writers are Mikhail Ievgravovich Saltikov (1826-89), a social satirist of pungent skill, and Sergei Timofeevich Aksakov (1791–1859), author of *the Family Chronicle*, a work of much social importance, written in perfect prose.

Ivan Alexandrovich Goncharov (1812–91) in his novel *Oblomov*, depicting an indolent, contemplative country squire, gave the word "Oblomovism" to the Russian language. Nikolai Semovich Leskov (1831–95) was the author of *Soborvane* (Cathedral Folk) and many short stories ; one of these, *Lady Macbeth of Mtensk*, is the subject of an opera by the modern composer Dmitri Shostakovich. There is Anton Pavlovich Chekhov (1860–1904), whose play *The Cherry Orchard* is known throughout the world, and whose other plays, *Uncle Vanya*, *The Three Sisters*, and *The Seagull*, have an assured place in that poetic drama which deals with the permanent clash between men of dreams and men of action. Chekhov also wrote short stories of great merit, and in his own day it was the stories which first brought him fame, though now it is on his plays that his reputation chiefly rests. In the plays, he avoided the intentional vagueness which

characterises his tales. His drama, though psychological, is never hesitant, and what in a less skilful dramatist would fail to convince by its seeming dreaminess in Chekhov's plays holds the audience by the intensity of the interest.

The tradition established in this grand age of Russian literature was continued by two notable realistic writers, Ivan Bunin (b. 1870)—awarded a Nobel prize, 1933—and Alexander Kuprin (1870–1938). Bunin's fame rests on *The Village*, *Sukhodol*, and *The Gentleman from San Francisco*. Several of Kuprin's novels have been translated into English ; best known are *The Duel*, *The Bracelet of Garnets*, *The Swamp*, and *Yama* (The Pit). He is a master of the short story. Dmitri Merezhkovski (1866–1941) was the author of esoteric volumes. *The Forerunner*, a story of da Vinci, has been widely read in English. Following the sensation caused by Gorki, Leonid Andreyev (1871–1919) came into vogue, first as novelist then as playwright. In poetry, Alexander Blok (1880–1921), author of *The Twelve*, and Andrey Bely (1880–1934), had tremendous influence.

LESSON 13

The Literature of the U.S.S.R.

The Revolution of 1917 was an event which marked the end of an epoch and the beginning of a new age in what became the Union of Soviet Socialist Republics. It caused sharp lines of division among writers. One group, which included some popular but no great authors, fled abroad and gradually died out while still writing against the new régime. A comparatively small group of authors, including Gorki and Mayakovsky, openly joined the Revolution.

Literature tended to become propaganda, and it is a broad fact of literary history in general that whenever literature changes to propaganda, art is sacrificed. Very few works of literary importance were produced during those first years of turmoil, war, famine, and social precipitation, and what did appear was the work of writers already established—Gorki and Mayakovsky, for example. But the traditions were never abandoned. Writers still followed the 19th century Realists, Symbolists, and Romantics. They kept to the old forms. It was only the thought which changed.

Carriers of Culture

Those pre-Revolution authors who accepted the Revolution are of real historical importance, for they became the carriers of culture and literature from the great age to the new age. They carried over the old tradition and adapted it to the new circumstances. Among the most noteworthy is Alexei N. Tolstoy (1882–1945), once Count. His trilogy *The Road to Calvary* portrays Soviet achievement and, with Sholokhov's work, reaches the apex in fiction. Another writer who has devoted his talents to the new order is Ilya Ehrenburg (b. 1891), a prolific journalist. His writings give the impression of haste, and thereby lose in solid worth. His novels *In a Moscow Street* (1927) and *The Fall of Paris* (1942) probably represent his best work.

Other important writers from pre-Soviet days are Alexei Remizov, Mikhail Prishvin, and Evgeni Zamyatin. Zamyatin wrote a novel called *We*, which the state considered to be politically unsuitable for publication in the Soviet Union ; they allowed it to appear abroad.

Head and shoulders above all these was Alexei Maksimovich Peshkov (1868–1936), known to the world as Maxim Gorki (the pen-name means bitter, and that word describes much of his work). Gorki wrote novels, plays, short stories, essays, and articles. He was famous long before the Revolution. Of Gorki's works, those of his latest period are the best : *Childhood*, *In the World*, *My Universities*, *Reminiscences of Tolstoy*, and *Fragments from My Diary*. They are all in the old tradition and, like all his work, are powerful documents of acute observation and truth.

Revolutionary Poets

Russia, like most of Europe, has experienced a decline in poetry since the beginning of the century, and since the Revolution there has been little improvement. An indefinable malady seems to have struck poetry everywhere. Nevertheless, in Vladimir Mayakovsky (1893–1930), Sergei Esenin (1895–1925), and Boris Pasternak (b. 1890) the Revolution found men of genius who continued the old tradition.

Mayakovski's name was established before 1917, but it was after then that he showed fullest development. He gave his work a truly revolutionary turn and thus attracted the admiration and encouragement of men in power who might not otherwise have noticed him or his verses. He became a propagandist for the new order ; having been a poet, he remained one.

Esenin was for a few years far more popular among the masses, though at times his verses so lacked the revolutionary ingredient as to be frowned upon by authority. Most of his work is lyrical, though in *Pugachev* he attempted

(without much success) to write an epic. There is great disillusionment with life in his last verses; this ended in Esenin's suicide, an example which was followed five years later by Mayakovsky.

Pasternak's poetry is more difficult, more complex, and has a deeper cultural background than that of Mayakovsky or Esenin. He is now regarded as a better poet than either, one of the greatest of the new age. There is freshness in his work, and a sparkle rarely found in that of his contemporaries. It is individual rather than revolutionary.

New Age Dramatists and Novelists

The theatre of the new age, though vast, must be briefly dismissed—because of its quality. In 1933 most Russian critics were bewailing the shortage of good new plays. Those written to a political pattern enjoyed popularity, for now the masses were able to go to the theatre, which they love. But those new plays were very poor theatre in comparison with the works of Ostrovsky, Andreyev, Chekhov, and Gorki, and poor enough compared with the works of lesser preceding dramatists. The government was perturbed and in 1934 organized a competition in the hope of discovering more worthy talent. The result was a disappointment for everybody—not one play worthy of the prize was found in the Soviet Union. By 1940 there was improvement. Encouraged by the state and by the lucrative awards awaiting them, new dramatic authors began to come forward. If masterpieces of the theatre are not yet forthcoming, great promise has manifested itself in such writers as V. Kataev, who wrote *Squaring the Circle*, A. Afinogenov (1904–1941), author of *Distant Point*, Konstantin Simonov, and Alexander Korniechuk. Simonov's play, *The Russians*, was produced in London at the Old Vic. Korniechuk's most successful plays are *The Front* and *Guerillas of the Ukrainian Front*.

The novel in contemporary Russia overshadows every other literary form, though the short story sometimes runs it close. Isaac Babel (b. 1894) carried on the romantic tradition in works of merit, especially in his *Red Cavalry*. Vsevolod Ivanov (b. 1895), another romantic, wrote of his native Siberia in *Armoured Train No. 14-69* and other dynamic works. His long novel (it runs to several volumes) *The Adventures of a Fakir* fell back on traditional realism. Konstantin Fedin (b. 1892) reminds one of Gogol in his slow-moving, elaborate novel *Anna Timofevna*, dealing with a woman's life of suffering and sacrifice; in *Cities and Years* he shows great literary talent and notable originality. Leonid Leonov (b. 1899) has for his favourite theme the clash between village and town—some of his characters are so subtly drawn as to remind one of Dostoyevsky.

Two works of outstanding merit established the reputation of Venyamin Kaverin (b. 1902)—*The Anonymous Artist* and *Fulfilment of Desires*. Mikhail Sholokhov (b. 1905) published in 1926 his first great novel *And Quiet Flows the Don*, a work which, with its successors, *Virgin Soil Upturned* and *The Don Flows down to the Sea*, comes closer to Tolstoy's *War and Peace* than any novel of the period, and places the author among the best novelists of the new age.

Proletarian Writers

Under a movement sponsored by the state to encourage proletarian writers, output of books increased enormously. Literature expanded. By 1940 the quantity of the literature of the new age in Russia had reached phenomenal dimensions, and therefore any account of it must needs be incomplete. Here are some of the most important authors, many of whose works have been translated into English: Valentin Kataev (*Forward, O Time !*, *Lone White Sail*), P. Romanov (*Three Pairs of Silk Stockings*), M. Zoshchenko (*The Woman Who Could Not Read*, *The Wonderful Dog*, and other volumes of humorous short stories), Ilya Ilf and Eugen Petrov, killed in action in 1942 (collaborators in *Diamonds to Sit On* and *The Little Golden Calf*), Fedor Gladkov (*Cement*), Makarenko (*The Road to Life*), Yury Herman (*Antonina*), Semyushkin (*Chukotka*), A. Fadayev (*The Nineteen* and *The Rout*), Furmanov (*Chapayev*), Serafimovich (*Iron Flood*), Pilniak (*The Volga Flows into the Caspian*, *Mahogany*), and Korniechuk (*Rainbow*)..

LESSON 14

Dutch, Scandinavian, and Finnish

HOLLAND has a rich medieval literature. The French "roman courtois," here as elsewhere, produced a crop of imitations, but there were also native lyrics and religious and didactic poems. The mystic *Ruusroec* has become world-famous in translation. Drama took much the same course as in other countries; there is a Dutch precursor of *Everyman*—*Elckerlyk*. In prose, the theologian Erasmus (1467–1536) wrote copiously, but he used the scholarly Latin rather than the vernacular.

The Renaissance quickened output. In the 16th century there is little of note, beyond plays and translations from the Psalms. The 17th

century, however, was a great period. Of the many writers who graced this Golden Age, five stand out. Pieter Hooft (1581–1647) wrote lyrics and some magnificent plays ; he was also a historian. He had travelled widely in France, Germany, and Italy, and was under the influence of Italian culture. His own influence upon his contemporaries was immense. Gerbrand Bredero (1585–1618), a shoemaker's son, became a poet and dramatist who pleased the popular taste ; his best-known play is *The Spanish Brabander*. Joost van den Vondel (1587–1679) began by translating lyric drama and other verse from the French, Latin, and Greek, and went on to write plays which are remarkable for their sublime poetry. His *Lucifer* is believed to have influenced Milton, who knew Dutch. Jacob Cats (1577–1660) is not a great poet ; his importance lies in the fact that he typifies contemporary thought and outlook. The century also gave us the famous philosopher Spinoza, who wrote voluminously in Latin.

The 18th century reflects the influence of English literature. Van Effen (1684–1735) published *The Dutch Spectator*, a lively imitation of its English prototype. Elizabeth Wolff-Bekker (1738–1804) and Agatha Deken (1741–1804), writing in collaboration, brought out novels in epistolary form, modelled on those of Richardson, but more finished.

The 19th century was heralded by Willem Bilderdijk (1756–1831), a distinguished poet and a noble character. Another writer whose sound thinking and frank expression made a strong impression was Multatuli (1820–87), whose real name was Eduard Doúwes Dekker. His completely natural prose brought about a revolution in Dutch literature, and is seen in the largely autobiographical *Max Havelaar*.

Dutch Literature

There has been since 1880 a great flowering of Dutch literature. The poets include Willem Kloos, Jacques Perk, and Herman Gorter. Frederik van Eeden (1860–1932) wrote poetry and plays but excelled as a novelist ; his three-part *Little Johannes* and *The Deeps of Deliverance* have been translated. An outstanding novelist was Louis Couperus (1863–1923), whose work has been extensively translated ; he is best known for his *Books of the Small Souls* (1901–3), *Old People and Things That Pass* (1906), and *The Comedians* (1917). *Iskander* (1920) is a fine historical novel dealing with Alexander the Great. Louis Couperus shows a real mastery of his themes, which he handles with Tolstoyan imagination. He has also written short stories, sketches, and essays. An other Dutch writer who is well known in Great Britain is Jan Fabricius (b. 1871), dramatist and novelist. He is often prolix and lacking in literary grace, but he has verve, and *The Son of Marietta* was a deserved success. Israel Querido (1874–1932), a distinguished critic, won popularity as a novelist, and Herman Heijermans (1864–1924) will be best remembered in Britain for his novel *The Rising Sun* and for a short play, *A Case of Arson*.

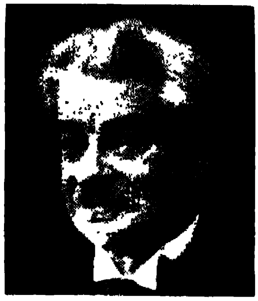
ERASMUS. Holland's great humanist did much to advance the Revival of Learning. He advocated a return to "first things" in Christian teaching. His work is mainly in Latin.
Holbein The Louvre photo, Giraudir.

Scandinavian Literature

The literature of Scandinavia begins with the Icelandic Eddas, which fall into two groups. The Elder Edda, or Poetic Edda, consists of epic poetry, often fragmentary, narrating the primitive myths and early history of the Norse settlements. Here is the first mention of the Volsungs and the Nibelungs, whose stories have inspired so much magnificent literature. This material was collected in the 12th century, but much of it dates from two or three centuries earlier ; it was not made known to the world until 1643. The Younger Edda, or Prose Edda, was collected, and probably rewritten, by Snorri Sturluson (1179–1241), a poet whose greatness has been unmatched in Scandinavian literature down to present times. This Edda includes a sort of treatise on poetry, with rules.

There is a vast amount of saga material, mainly Icelandic, dating from the 12th century. The sagas are prose epics, based on the old legends. Snorri Sturluson's *Heimskringla* enshrines many of them. Famous, too, are *The Grettir Saga*, *The Njal Saga* (Burnt Njal), and the romantic *Saga of Laxsdael*, which gives the story of Gudrun. In our own time, the work of Gunnar Gunnarson (b. 1889) is available in translation. Gunnarson has written in Icelandic and in Danish. His best known works are *Guest the One-Eyed*, *Seven Days' Darkness*, and *The Sworn Brothers*.

Henrik Ibsen



Georg Brandes

Björnstjerne Björnson

August Strindberg

In early Swedish literature the most interesting work was done by religious writers, of whom Saint Brigitta (1303–73) is most notable. Father Mattias (d. 1350) began a translation of the Pentateuch which was completed by Johannes Bude (d. 1494). In the 17th century the poet Stiernhelm (1598–1672) was influential; his epic *Hercules* is a great achievement.

During the 18th century the outstanding literary figure was Baron Ludwig Holberg (1684–1754), who, besides writing on historical and philosophical subjects, was an accomplished dramatist. In Sweden there were two personalities whose influence has been world-wide —Emanuel Swedenborg (1688–1772), scientist and mystic, and Linnaeus (1707–78), the botanist; both wrote in Latin but were widely translated. Johann Kellgren (1751–95) and Thomas Thorild (1759–1808) brought to the North the classicism of the French writers and the pre-Romanticism of Rousseau. The Swedish Academy was founded in 1786 by Gustavus III, himself a fine playwright; it was modelled on the French Academy, but had 18 members instead of 40.

Danish Romanticism

It was in Denmark that Romanticism was best exemplified. Johannes Ewald (1743–81) is among the great lyric poets of the world; his *Balder's Death* has been translated. In 1775 he founded the Danish Literary Society. Adam Oehlenschläger (1779–1850), poet and dramatist, was publicly crowned Scandinavian King of Song in 1829. Of his volumes of poetry, *The Golden Horns*, *Axel and Valborg*, and *The Gods of the North* are known in translation, as also his fairy-tale drama, *Aladdin*. Hans Christian Andersen (1805–75), another Dane, is famous for his immortal *Fairy Tales*; he was, too, a successful writer of novels, travel books, and plays. Ranking with Andersen and the German Grimm brothers as writers of fairy tales are Peter Asbjörnsen (1812–85) and Jörgen Moe (1803–82) in Norway; both were learned in folk-lore, and their collaboration produced the great collection of *Norwegian Folk Tales*, which has been frequently translated; in English, Sir George Dasent's version is best known.

During this period Sweden's outstanding writer was Esaias Tegnér (1782–1846), a bishop and professor who was one of the leaders of the Gothic League, a group of young literary men meeting in Lund. His best work is in *Axel* and *Frithiof's Saga*, which have been translated. The Finnish poet Johan Runeberg (1804–77) wrote mostly in Swedish; his *King Fjalar* and *Ensign Stahl's Adventures* have been translated. The latter contains the poem *Our land, our land*, Finland's national song.

Prolific Authors

The latter part of the 19th century was a great period in Scandinavia. Denmark had in Georg Brandes (1842–1927), a Jew, one of the most influential of European critics. In Norway, Henrik Ibsen (1828–1906) and Björnstjerne Björnson (1832–1910) aroused interest throughout the world by their social dramas. In Sweden, August Strindberg (1849–1912) dominated literature for at least fifty years. Brandes' most famous work is the 6-volume *Main Currents in Nineteenth Century Literature*, first delivered as a series of lectures. Art, he taught, must not be satisfied with the ideas and ideals of mediocrity; great art seeks a defiant independence and an "aristocratic absolutism." Brandes became a European celebrity. His volumes of essays, biographies, and expositions have influenced writers of every country.

The revolutionary plays of Ibsen provided the impetus for changes in the social outlook of Europe. He attacked existing conventions and the hypocrisy of bourgeois society. Because of his mastery of dramatic technique, Ibsen may be called the father of the modern drama; *A Doll's House* is a model for playwrights. In the disciplined dramatic form he could compress wide-sweeping material. The long list of his plays includes *Lady Inger of Ostraat* (1854), *The Warriors at Helgeland* (1858), *Love's Comedy* (1858), *The Pretenders* (1864), and the dramatic poems *Brand* (1866) and *Peer Gynt* (1867),

The League of Youth (1869), the vast two-part *Emperor and Galilean* (1873), *Pillars of Society* (1877), *A Doll's House* (1880), *Ghosts* (1881), which caused a storm because of its exposure of the hereditary nature of venereal disease, *An Enemy of the People* (1882), *The Wild Duck* (1884), *Rosmersholm* (1886), *The Lady from the Sea* (1888), *Hedda Gabler* (1890), *The Master Builder* (1892), *Little Eyolf* (1894), *John Gabriel Borkman* (1896), and *When We Dead Awaken* (1900). All have been translated into English by William Archer, many by Norman Ginsbury.

A most prolific author who was regarded as the outstanding figure in Norwegian literature at this time, Björnson wrote plays, poetry, novels, and short stories. It is as a dramatist that he is best known. In romantic drama he wrote four plays on Sigurd the Bastard and a tragedy on Mary Stuart ; an amusing comedy, *Newly Married* ; and a symbolic drama, *Beyond Our Powers*. Like Ibsen, he also wrote social drama with a purpose. Björnson's poetry has real beauty. As a novelist, he began with stories of peasant life and ended with realistic stories. His work has been translated in its entirety, and it earned him the Nobel prize for literature in 1903.

Strindberg is Sweden's greatest dramatist, and his most famous plays, *The Father*, *Countess Julie*, *The Creditors*, and *The Dance of Death*, are works of genius, though their morbid pathological themes and the bitter intensity of treatment prevents them from winning popularity on the stage. Strindberg made three unhappy marriages, and was at one time perilously near insanity ; his work reflects the mental torments he endured. He was, however, capable of much grace and humour, as seen in some of his excellent short stories. A most versatile writer, he produced several novels, of which *The Red Room* is unequalled in its mordant criticism of contemporary society.


Sigrid Undset


Selma Lagerlöf

The Novel in Norway

As Ibsen and Björnson are called the fathers of modern Norwegian drama, so Jonas Lie (1833–1908) is justly called the father of the modern novel in Norway. His first novel, *The Visionary*, attracted attention and was followed by *The Barque*, *Future*, *The Pilot and his Wife*, and other novels, until in 1882 *Go Ahead !* showed that here was a writer of the highest importance. In *A Maelstrom* and *A Marriage* he maintained the same high standard, and his two volumes of short stories, *Trolls*, showed a wide range and sure touch. Another outstanding writer was Alexander Kielland (1849–1906), whose first book, *Novel-letter*, won immediate popularity ; he wrote a number of successful novels and plays.

Norwegian Authoresses

A fine Norwegian authoress was Sigrid Undset (1882–1949). In her youth she supported herself by doing clerical work for small pay, living the humdrum existence which she was afterwards to depict so faithfully in her novels. In 1911 she published *Jenny*, a novel which won the approval of her own country's critics and extended her fame abroad. Her most important work is in the two great cycles, *Kristin Lavransdatter*, and *The Master of Hestviken*, romances of the remote saga period written with a realism, a breadth of knowledge, an imaginative sympathy, and a wide sweep that afford comparison with the work of the leading Russians. Sigrid Undset is an important addition to European literature, though there could be no more intensely Norwegian writer. In 1928 she was awarded the Nobel prize.

Selma Lagerlöf (1858–1940) was a Swedish woman who received the Nobel prize in 1909. Her most popular work is *Gösta Berling's Saga*, a lengthy modern prose epic, vast in scope and written in a style that is both lyrical and thrilling. Her short stories and her long novel *Jerusalem* are even better literature. Several of her books are available in translation.

The 20th century for Denmark, Norway, and Sweden brought new values and a period of unrest and flux. In the first two countries, the chief characteristic is the role played by proletarian and peasant writers of the soil, among whom Andersen-Nexo and Knut Hamsun may be instanced. In Denmark the most important novelists are Johannes V. Jensen (1873–1950), whose *Danes*, and *The Fall of the King*, *The Long Journey*, and *The Cimbrians*, together with his series of *Himmerland Stories*, entitle him to a place of honour among European writers ; and Henrik Pontopiddan (1857–1943) who wrote stories of country life, of which *The Promised Land* has been translated. Martin Andersen-Nexo (b. 1869) won popularity ; his five-volume *Ditte, Daughter of Man* has been translated. The greatest of modern Danish poets was Karl Gjellerup (1857–1919), who in 1917 shared the Nobel prize with Pontopiddan.

The success of Knut Hamson (1859–1952) dates from *Hunger* in 1890.

In English translation his *Growth of the Soil* appeared his most powerful novel, the very simplicity of its theme lending it almost the weight of an epic. It won him the Nobel prize in 1920. The finest novels of Johan Bojer (b. 1872) are probably *The Power of a Lie* (1903) and *The Great Hunger* (1916).

In Sweden, Romanticism is combined with realism and tinged with a gentle scepticism that is well exemplified in the work of Hjalmar Söderberg (1869–1941). This attractive novelist had a keen eye for human weaknesses, including his own. He is at his best in the short story, of which he published several collections, notably *Doctor Glas*. He also wrote three plays, *Gertrude*, *Evening Star*, and *The Hour of Fate*. Two other modern Swedish authors worthy of mention are Hjalmar Berhman (b. 1883) and Anders Osterling (b. 1884), whose work is always interesting and often sparkling, though not always profound.

The literature of Finland has been, until the 20th century, outside the general European currents. Authors have been satisfied with simple local themes, and the public is satisfied with imported literature, though in the few years preceding the Second World War there were signs that young writers wished to show a native originality. The national epic known as the *Kalevala*, or *Land of Heroes*, remains the one outstanding work of literature which this country has produced. Of Finland's modern writers, the most gifted was Juhani Aho (1861–1924). He followed the French realists in his treatment of contemporary life, and his best works are *Enris*, *The Fortress of Matthias*, and *Finland's Flag*.

For the rest, it is fair to say that Finnish literature is chiefly influenced by Swedish. Madame Aino Kallas has done distinguished work as a Finnish-Estonian novelist and playwright, and is known abroad in translation.

LESSON 15

Polish, Czech, and Hungarian

BEFORE the 16th century most Polish authors wrote their works in Latin. The only old work in Polish of other than historical or philological importance is the Bible, which is said to have been translated for Queen Sophie about the year 1455. Even this translation is incomplete. It was not until the poet Jan Kochanowski (1530–84) had set an example to his fellow-countrymen by writing in the Polish language his beautiful *Lamentations* on the death of his daughter that anything worthy of the name of native literature appeared. By this work and others in verse, including a play in iambics called *The Despatch of the Greek Ambassadors* (incidentally, the first important drama in the language), Kochanowski came to be called the Prince of Polish Poets. Kochanowski's poetry holds an important place to-day in the anthologies. His epigrams, not unlike those spirited, witty sayings which are sprinkled throughout Cervantes' *Don Quixote*, are even more esteemed.

Poland's Greatest Poet

An outstanding name is Adam Mickiewicz (1798–1855). He is considered to be the greatest Slavonic poet after the Russian Pushkin, whose friend he was. Mickiewicz is undoubtedly Poland's greatest poet, and if his name is little known outside his own country it is because few foreigners take the trouble to learn its difficult language. Like the work of Pushkin, that of Mickiewicz is difficult to translate. His themes are for the most part essentially national: Poland's history, legends, superstitions, folk-lore, and struggles. His sonnets, especially, are beautiful. *Pan Tadeusz*, a long narrative poem dealing with a national hero, is his most popular work and probably his masterpiece. *Konrad Wallenrod*, another epic, is almost its equal. For a time Mickiewicz held the chair of Slavonic studies in Paris, and during that period published four volumes of literary history and criticism. They are little read now. He had become immersed in religious mysticism, and the resultant medley is of little importance either as criticism or as mysticism. There are translations of *Pan Tadeusz* and *Konrad Wallenrod*.

The second great Polish poet after him is Julius Slowacki (1809–49), a Romantic who was influenced by Byron and by Victor Hugo. His finest pieces are *Hugo*, *The Monk*, *Lambro*, and a Dantesque work called *Anhelli*.

Growth of the Polish Novel

The first popular novelist was Joseph Korzaniowski (1797–1863). Joseph Ignatius Kraszewski (1812–87), another and possibly a better novelist, had a prodigious output. A mere selection from his fiction was collected and published in the 1870s. It consists of no fewer than 102 volumes. Strangely, the work of Kraszewski considered of most value to-day is in national archaeology and aesthetics, not literature.

No important novelist appeared until Henryk Sienkiewicz (1846–1916). He has the honour of being the first author of his nationality to achieve a European reputation. It is by the novel *Quo Vadis ?* that Sienkiewicz is best

known throughout the world. This book appeared in 1895 and in English in 1896. It is a study of Roman society under Nero, with special reference to the tribulations of the Christians. The general picture is convincing, the scholarship good. But it is in his remarkable powers of realistic reconstruction and description that the author excels, and this quality, together with the ability to tell a moving and in parts a religious story, brought the book success not only in Poland but also among the peoples of the thirty languages into which it was translated. It has been dramatised and filmed. Sienkiewicz's best work is a trilogy consisting of *With Fire and Sword*, *The Deluge*, and *Pan Michael*, written in stately prose. His *Teutonic Knights* appeared in English translation in 1943.

Modern Period

The success of Sienkiewicz focused on the novel attention which had hitherto been devoted to poetry, though the greatest poet of modern Poland, Jan Kasprowicz (1860 1926), was never sufficiently moved by it to turn to prose. Stefan Zeromski (1864–1925) and Wladislaw Stanislas Reymont (1867–1925)—the latter a Nobel prizewinner—wrote little but novels. Zeromski deliberately followed and imitated Sienkiewicz, though he chose different themes. His most successful work is *The Ashes*, a novel dealing with the Napoleonic period. Reymont has been called the Polish Zola. His best work is a tetralogy that has been translated into English under the title *The Peasants*. It may well be that posterity will say this is the greatest novel Poland has so far produced, because of its accurate psychology.

Between the two World Wars the number of poets decreased ; that of prose writers increased. Only one name among the latter is outstanding : Ferdinand Ossendowski. His books, relating amazing experiences in a remarkable manner, won him world-wide popularity. In the hurly-burly of the re-establishment of a new state, authors who might have been producing literature turned to national problems. Literature suffered. There has not yet been a Golden Age of Polish literature.

Czech Literature

Czech literature is comparatively new—one hundred years ago there was little of it, apart from some interesting lyrical poetry. By about 1850, but hardly before, there was a reading public for works in the Czech language. F. L. Celakovski (1799 1852) made an important collection of old Czech songs, and the relaxation of Austrian rule in 1850 encouraged printers, publishers, and nationalist authors to disseminate old traditional works and attempt to produce new ones. Among the important 19th-century authors was Jan Neruda (1834–91), who wrote stories of middle-class life in Prague.

The greatest name in Czech literature is that of Jaroslav Vrchlicki (1853–1912), who probably holds the world's record for poetic output, with 70 volumes. To him must be given the honour of stimulating the public appetite for literature in the mother tongue, which Vrchlicki enriched and proved to be an admirable literary medium.

The Real Beginning

In 1895 a "Modernist Manifesto," signed by a group of poets, called upon writers to observe a code not very dissimilar from that enunciated by the Danish critic Brandes. This was the real beginning of modern Czech literature. Its greatest exponents have been J. S. Machar (1864–1942), Otakar Brezina (1868–1940), Fráña Sràmek (b. 1877), all of them little known outside their own land.

Two Czech writers of our times achieved world-wide reputations. The first, Karel Capek (1890 1938), is best known in England for his remarkable dramas *R.U.R.* and *The Insect Play* (the latter written in collaboration with his brother Joseph) as well as for *Letters from England* and other travel books, novels, and short stories. The second is Jaroslav Hasek (1884–1923), who had published many short stories before the First World War, and after it began *The Good Soldier Schweik*—a satire which did much to encourage Czech nationalism. Only four of the projected six parts were written. This book had an extraordinary popularity throughout Europe in the 1920s and 1930s.

Hungarian Literature

Hungary is to be numbered among the few countries in which a king laid the foundations of a national literature by precept and practice. To the Hungarians the name of King Matthias Hunyadi (*c.* 1458–90) is that of an immortal, for he it was who evoked the national poetic genius, and from his time until to-day, with many periods of progress and many of vicissitudes, there have never ceased to be authors who worthily used their difficult language. But only in the novel have Hungarian writers extended their fame outside their own country, and then not to any great extent.

Maurus Jókai (1825–1904) is perhaps the most popular novelist Hungary has produced ; it is claimed for him that there has been no more brilliant narrator since *The Arabian Nights*. His best works deal with the life which he found around him. Perhaps his best novel is *The New Landowner*, a witty picture of the absolutism introduced by the Austrians after their seizure of the country. His *Hungarian Nabob* depicts the aristocracy in all its haughtiness and insolence. The hostile, revolutionary attitude of

the Hungarians towards their Austrian masters is shown in *The Baron's Sons*, *Political Fashions*, and *Battle Pictures*. In his *Novel of the Coming Century* he gives highly prophetic descriptions of modern warfare, including a battle in the sky between two airships.

Kálmán Mikszáth (1849–1910) is the only Hungarian novelist who can be compared with Jókai, and then only because of one novel, *The New Zrinyiász*, in which the hero Zrinyi rises from his grave to find himself in the altered conditions of the new Hungary.

LESSON 16

Oriental Literature

THE major literatures of Europe have been treated at some length ; those of Asia would require equal (or more) space if discussed with the same thoroughness. The most that can be attempted here is a general outline of the main literatures, with suggestions for future reading.

Literature of China

Of all Asiatic literatures, the most comprehensive and varied is that of China. It covers a period of some 4,000 years ; it shows detailed histories, poetry, essays, works on art, music, the sciences, agriculture, linguistics (of China and near lands), philosophy, geography, travel, indeed all human activity is represented somewhere (and usually at great length). Among the numerous philosophers, Confucius gained the lead in the centuries just before the Christian era, and his works became the Chinese classics. From the 4th century B.C. scholars began to compile anthologies of superb poetry and prose, and many such collections have been preserved. Each dynasty had its own official history (running to several hundreds of volumes), and each compiled its own record of its famous men and women and their works. (*See The Chinese Classics*, trans. by J. Legge, 5 vols., Hong-kong ; H. A. Giles, *Gems of Chinese Literature*, 2 vols., published in London.)

India's Literature

India runs China fairly close in some divisions of literature. The literary language was an early Sanskrit ; a modified later form is still used by Brahmans. In this tongue and in Pali are epics, compendia of laws, inscriptions, descriptive and emotional verse, histories, and philosophic and religious writings. Romantic novels, dramas, essays of literary criticism, and commentaries on early texts abound. Among the earliest non-archaeological writings are the Upanishads and the Vedas, basis of Hindu religious belief. All the vernaculars of northern and central India (except for a few non-literary tribal languages) are descended from one of the Sanskrits, and the modern writers like Tagore (who wrote in Bengali) have followed fairly closely the early literary tradition. (*See* A. B. Keith, *A History of Sanskrit Literature*, O.U.P. ; S. Radhakrishnan, *The Principal Upanishads*, Allen and Unwin ; Narada, *The Dhammapada*, John Murray, also translation by S. Radhakrishnan, U.O.P.)

Hebrew and Arabic

Ancient Hebrew literature is best represented by the Old Testament. (*See* G. F. Moore, *The Literature of the Old Testament*, O.U.P. ; and the Talmud, in *Everyman's Talmud*, Dent.)

Arabic literature is comprehensive in volume and scope. Many ancient Greek works are preserved to us only in medieval Arabic translations, especially those dealing with aspects of early science, astronomy, mathematics, physics, etc. Purely Arabic works are usually of a deeply reflective or mystic character ; the mystic poets, Ghazali, Ibn al-Arabi, al-Mutanabbi, and Abu Nawas have attracted innumerable Western students. The Koran is often quoted as superb in its style apart from its religious content. (*See* H. A. R. Gibb, *Arabic Literature*, London ; *The Koran*, trans. by E. H. Palmer, World's Classics, O.U.P. ; *An Arab Philosophy of History*, trans. by C. Issawi, London.)

Persian Literature

Persian literature, like that of the Arabs, abounds in mystic poetry, moral tales, philosophical and scientific speculation, and religious writing in prose and verse. The so-called *Arabian Nights* (*see* translation by Burton, London), is a collection of stories, mostly of Persian origin with a few Indian, ancient Egyptian, and some three or four purely Arab stories. The great epic *Shah Namah* (Record of the Kings), by Firdausi, is a lasting monument of genius ; smaller works by Sa'adi (*Bustan* and *Gulistan*) and by Hafiz have been many times translated into European languages.

Japan and Indonesia

Japanese literature, based originally on that of China, soon developed a form of its own. It is totally unlike that of China from the end of the 9th century A.D. ; it has nothing to compare with the depth, sweep, or range of Chinese literature. It is the writing of the melancholy observer of the transitoriness of life, the light comment on the futility of human aspiration,

leaving aside all deep consideration and philosophical speculation. Apart from early poetry (*see* B. H. Chamberlain, *On the Poetry of the Japanese*, Tokyo ; J. L. Pierson, *The Manyosu*, 7 vols., Leyden), most of Japanese classic literature was written by women while men were engaged in the unending feudal wars. (See *Diaries of Court Ladies of Old Japan*, London.)

Indonesian literature is largely Buddhist, consisting of translations of and commentaries on the Buddhist canon. There is also much poetry of a romantic kind, a body of law treatises, and long histories. The Malay *Hikayat Abdullah* exists in English translations.

BOOK LIST

General. *Periods of European Literature*, ed. G. Saintsbury (Blackwood, 12 vols.) ; *Dictionary of European Literature*, L. Magnus (Routledge) ; *Studies in European Literature*, Janko Lavrin (Constable) ; *Main Currents in Nineteenth Century Literature*, G. Brandes (Heinemann) ; *An Encyclopaedia of Literature*, ed. S. H. Steinberg (Cassell).

French. *Short History of French Literature*, G Saintsbury (Oxford) , *History of French Literature*, K Butler (Methuen) , *Landmarks in French Literature*, Lytton Strachey (H.U.L.) ; *Literary History of France*, E Faguet (Fisher Unwin) ; *Histoire de la Littérature Française*, R Doumic (Hachette) ; *The Troubadours*, H. J. Chaytor (Cambridge Manual) ; *Literature of the French Renaissance*, A Tilley (Oxford) ; *Classical Movement in French Literature*, H E. Stewart and A Tilley (Oxford) ; *French Classical Drama*, E. F Jourdain (Oxford) ; *French Romanticists*, H E Stewart and A. Tilley (Oxford) , *History of French Versification*, L. F. Kastner (Oxford) ; *Contemporary French Literature, 1817–1921*, R Lalou (Hachette) ; *Contemporary Belgian Literature*, Bithell (Fisher Unwin).

Spanish. *A New History of Spanish Literature*, J Fitzmaurice-Kelly (Oxford) , *Spanish Prose and Poetry*, I. Farnell (Oxford) ; *The Genius of Spain*, S de Madariaga (Oxford) ; *Main Currents in Spanish Literature*, J. D M Ford (Constable).

Portugese. *Portuguese Literature*, A. F. G. Bell (Oxford) ; *Historia da Literatura Portuguese*, Mendes dos Remedios (in Portuguese).

Italian. *Literary History of Italy*, E G. Gardner (Fisher Unwin) ; *Italian Literature*, R. Garnett (Heinemann) ; *Epochs of Italian Literature*, C. Foligno (O.U.P , World's Manuals) ; *Italian Literature : Early Times to Dante*, trans. from Gaspary (Bell) ; *Romantic Age in Italian Literature*, A. Cippico (Medici Society) ; *Modern Italian Literature*, Collison Morley (Pitman) ; *The Renaissance in Italy*, Vols. IV and V, J. A. Symonds (Murray).

German. *History of German Literature*, J. Robertson (Blackwood) ; *Primer of German Literature*, I. T. Lublin (Allen & Unwin) ; *Classical Age of German Literature*, L. A. Willoughby (Oxford) ; *The German Classics*, M Muller (Oxford) , *Romantic Movement in German Literature*, K. Breul (Heffer) ; *Modern German Literature, 1880 1938*, Jethro Bithell (Methuen).

Russian. *Outline of Russian Literature*, M. Baring (H.U L.) ; *Russian Literature*, P. Kropotkin (Duckworth) ; *History of Russian Literature to 1881*, D. S. Mirsky (Oxford) ; *Contemporary Russian Literature, 1881–1925*, D S Mirsky (Oxford) ; *Modern Russian Literature*, D. S. Mirsky (Oxford · World's Manuals) , *25 Years of Soviet Russian Literature, 1918 1943*, Gleb Struve (Routledge) ; *An Introduction to the Russian Novel*, Janko Lavrin (Methuen) , *Guide to Russian Literature*, M. J Olgin (Routledge).

Scandinavian, Polish, etc. *Scandinavian Literature*, H. G. Topsoe-Jensen (Allen & Unwin) , *Icelandic Sagas*, W. A. Craigie (Cambridge Manuals) ; *Periods of Polish Literary History*, R. Dyboski (Oxford) ; *Modern Polish Literature*, R. Dyboski (Oxford) ; *Czechoslovakian Literature*, P. Selver (Allen & Unwin) , *Short History of Czech Literature*, F. A Chudobra (Routledge) , *Early Jugoslav Literature, 1000 1800*, M. S. Stanoyevich (Oxford) , *Hungarian Literature*, F. Riedl (Heinemann).

ITALIAN

***Our** Course in Italian aims at providing the essential vocabulary and the minimum of grammar necessary for the student to acquire a working knowledge of this beautiful and not difficult language.*

Courses in other modern foreign languages will be found in Vol. 2 (FRENCH), *Vol. 3* (GERMAN), *present volume* (SPANISH), *and Vol. 5* (PORTUGUESE *and* RUSSIAN). *The parent-language of Italian*—LATIN—*appears in Vol. 2. The Course on* PHILOLOGY, *which is complementary to the study of all languages, is in Vol. 5. The Italian section of the Course on* FOREIGN LITERATURE (*in the present volume*) *provides suggestions for reading.*

11 LESSONS

LESSON 1

Introductory: Italian Pronunciation

This Course consists of 11 Lessons. Some are a little longer than others, but the student need not concern himself with this but should concentrate upon learning so much of each lesson each day. If he is teaching himself, he should devote not less than one hour daily to study, and with an hour a day he should know sufficient Italian at the end of three months to be able to read almost anything.

The chief difficulty of Italian is the verb. This Course provides the utmost simplification that is practicable. Even so, there is much of the verb that need not be mastered on a first perusal, and this applies also to other parts of the Course.

In this Course, the "essential" vocabulary is given in Lesson 10 in a complete alphabetical list—an "all-purposes" list of words which must be known, whatever the purpose may be for which the language is studied. Words are more important than grammar. From the outset the student should use a notebook and copy into it not fewer than ten words that must be learnt every day. He will note that in the vocabulary given some words are in larger type than others. **Words in large type must be learnt first.**

Reading Italian

The student will notice that he is not overburdened with exercises in this Course, and for the very good reason that when he has worked through the grammar once, and learnt the vocabulary given in large type, he will be able to start reading Italian. The exercises given in the early stages have the English translation of the Italian text, and this will help to illustrate the workings of the language. Later only the Italian is given, and the exercise consists in working out the meaning without help. In other words, the method here is to make the student struggle to fathom the meaning. He may, if he wishes, write out a translation of these exercises, though this is not strictly necessary. But having once worked out the meaning, let him read the Italian text **over and over again** until he can follow the meaning without the slightest difficulty.

Italian is not a difficult language; and it is a very beautiful one. These two factors are a wonderful encouragement to the student. It has been estimated by reliable observers that only about one of every twenty-five students who have learnt French, Latin, or German at school ever pursues his studies much further. But once a student has tasted Italian (and this also applies to that other beautiful language Spanish), he seldom drops it. "He who begins well is half-way through the work" is an Italian proverb, and it applies particularly to the study of the language.

Let the student read and ponder over the Lesson in Vol. 2, page 666, on "How to learn a language." If he follows those instructions and the instructions given here, he can look forward with confidence to achieving an admirable working knowledge of Italian in a few months.

Alphabet and Pronunciation

The alphabet is the same as in English, except that **K, X, Y,** and **W** are never used in Italian, and **J** very rarely (in some old proper names). **X** is found only in the word **Ex** in such expressions as **Ex-ministro**, *Ex-minister*, etc.

There are two accents: the grave (`) and the acute (´), of which the grave is the more important.

The **grave** accent (`) has two uses. (1) It is placed over a terminal vowel to indicate that it must be stressed—for example, **lunedì** (*Monday*) is pronounced *loonaydee'*, and **onestà** (*honesty*) is pronounced *onnestah'*, in each instance the last syllable being more strongly stressed than the others. That is the general use of the grave accent.

But it is also used (2) to differentiate words of one syllable which would otherwise be identically written: thus **è** with the accent means *is*, and **e** means *and*. Similarly **chè** means *because*, and **che** means *that*; **dì** means *day*, and **di** means *of*; **là, lì** mean *there* and **la, li** mean *the*; **sì** means *yes*, and **si** means *oneself*; **nè** means *nor*, and **ne** means *some*, *of it*, *of them*; **dà** means *gives*, and **da** means *by* or *from*.

The **acute** accent tends to fall into disuse, except in text books and dictionaries, but it is a useful guide for the foreigner. In words of more than two syllables, it is used to indicate stress when this does not follow the general rule (for which see below). Thus: **único** (*single*, *only*) is pronounced *oo'nico* **pópolo** (*people*) is pronounced *po'poloh*. Strictly, there is *no* acute accent in Italian written by Italians for Italians. It is used throughout this Course as a *sign to indicate stress*, which when very irregular is also indicated by printing the stressed vowel conspicuously: **le fOrbici**, *the scissors*.

General Rule for Accentuation or Stress

The stressed syllable of every Italian word is the last but one unless indicated by a grave or acute accent.

Thus **caro** (*dear*) is pronounced *cah'roh*; **delicato** (*delicate*) is pronounced *delicah'toh*; **virtú** (*virtue*) is pronounced *veertoo'*; **ridicolo** (*ridiculous*) is pronounced *reedee'cŏhloh.*

In the above simple rule the student finds a complete solution of what is in some other languages (English and Russian, for example) the difficult problem of stress, and this, with the other Italian custom of giving **one fixed value to each vowel and consonant,** takes from Italian pronunciation those major terrors common in some other languages.

Yet there is one difficulty which the English-speaking learner must overcome at the outset. He must avoid the English tendency to utter "impure" vowel sounds. Take, for example, the English word *no* as spoken by a "cultured" person. It is not a pure *oh* sound. It has a very slight *oo* or *i* sound tacked on to it. This addition of a slight auxiliary vowel-sound to most vowels is a characteristic of the English language, and makes "cultured" English pronunciation so difficult for the foreigner. It should be noted that Irish, Scots and Welsh and some other English-speaking peoples do not pronounce their vowels in this manner, and for them Italian pronunciation comes easier.

All Italian vowel sounds are pure. This is of very great importance, and the student must from the outset make every possible effort to pronounce his vowels with the utmost clarity and purity. Thus, when saying the Italian word **no**, let the *oh* be round, clear and *finish with a pure oh sound.* Let the beginner not hesitate to give full value to the simple vowel sounds noted below, repeating them again and again until he has eliminated every tendency to treat them as impure English vowels.

The Simple Vowels

A,	pronounce as *ah*,	almost as the	**a** in *father*, *art*, *arm*.
E	,, ,, *eh*,	,, ,, ,,	**ê** in *fete*, or *a* in *lame*.
I	,, ,, *ee*,	,, ,, ,,	**ee** in *bee* or *e* in *me*.
O	,, ,, *oh*,	,, ,, ,,	**oh** in *note*.
U	,, ,, *oo*,	,, ,, ,,	**oo** in *cool*, *fool*, or *u* in *rule*, and the same sound shorter as in *to*, *foot*.

When two or more vowels come together in Italian, each is pronounced clearly. When **i** and **u** come before other vowels, the **i** and **u** are pronounced very short. Thus: **paura** (*fear*) is pronounced *pah-ŏŏ'ra*; **Europa** (*Europe*) is pronounced *Eh-ŏŏ-roh'pah*; but **bianco** (*white*) is pronounced almost *byahn'co*; and **buono** (*good*) is pronounced almost *bwoh'no*.

The **i** and **u** coming before other vowels make the only true diphthongs in Italian. All other vowel combinations should be pronounced to give a clear-cut value to each vowel. Thus **miei** (*mine*, masc. pl.) is pronounced *myeh'ee*. Endings in **-io, -ia** make usually one syllable pronounced *yo* or *ya*.

When a word ends with an unaccented vowel, and the next word begins with a vowel, then the vowel at the end of the first word is dropped. Thus **tutto** (*all, altogether*) and **altro** (*other, otherwise*) when written together become **tutt' altro** (*quite otherwise*). This is for euphony and, as will be seen later, is very frequent in Italian.

Consonants

Italian consonants are pronounced like the English, with the following exceptions: **C, G, H, R, S, Z.**

NOTE WELL:

C before **e** or **i** is pronounced like the English *ch* in *church* or *cheap*. Thus **cena** (*supper*) pronounce *chay'na*. **Città** (*city*) pronounce *chittah'*—sound each **t** distinctly and put the stress on the last syllable. The word **cello** in English is borrowed from Italian, and so the **c** is pronounced like our *ch*. **c** before **a, o, u** or a consonant is always pronounced like the English *k*. Thus **banco** (*bank*), pr. *bahn'ko*.

CC before **e** or **i** pronounced like double English *ch*. Thus **accento** (*accent*), pr. *ahtchen'toh*.

CH is always pronounced like English *ch* in *chemist* or *k*. Thus **chiesa** (*church*), pr. *keeay'sah*. **perchè** (*why, because*), pr *perkay'*.

G before **e** or **i** sounds like English *g* in *gem* or *j* in *jest*. Thus **gelo** (*frost*), pr. *jay'loh*; **giorno** (*day*), pr. *johr'no*. **g**, before **a, o, u** and a consonant is like the English hard *g* in *get*, *gone* Thus **gallo** (*cock*), pr. *gal'lo*.

GG followed by **e** or **i** is pronounced like English *d-j* Thus **oggi** (*today*), pr. *odj'ee*.

GH is always pronounced hard like *g* in *get* or *gh* in *ghetto*. Thus **ghirlanda** (*garland, wreath*), pr. *geerlan'da*.

GL when followed by the vowel **i** is said to be "liquid" (like French *ll mouillé*, or Spanish *ll*) and has a sound like the English *-lli-* in *brilliant* or *million*. Thus **bottiglia** (*bottle*), pr. *botteell'ya*. **Egli, gli** (*he, to him*), pr. *ayl'yee, lyee*. But note that Italian **gl** is pronounced as in English when followed by an **i** that is followed by another consonant. Thus **negligente** (*negligent*) pr. *naygleejen'tay*; **Anglicano** (*anglican*), pr. *anglicah'no*.

GN is also called a "liquid" sound. It resembles the French *gn*—in *Boulogne*, or the Spanish *ñ* in *Señor* and the English *-ni-* in *union* or *onion*. Thus **bagno** (*bath*), pr. *bahn'yo*; **Incógnito** (*incognito*), pr. *eencon'yeeto*.

GU is always pronounced like the English *gw*. Thus **guerra** (*war*), pr. *gwerra*; **guida** (*guide*), pr. *gwee'da*.

H is always silent in Italian. Thus **ho, hai, ha** (*I have, thou hast, he has*), pr. *oh, ah'ee, ah*.

QU is always pronounced like English *kw*. Thus **questo** (*this*), pr. *kwes'to*.

R is well rolled and pronounced with the tip of the tongue against the teeth. Thus **raro** (*rare*), pr. *rah'ro*.

S is hard, like English *ss* in *moss*: **casa** (*house*), pr. *kassa*. Followed by a consonant, it is like English *s* in *some, such*. Thus **spedire** (*to expedite, dispatch*), pr. *sspaydeer'ay*.

Note that initial **s** followed by a consonant is called "impure s" and it is pronounced soft

like English **s** in *rose* when it comes before b, d, g, l, m, n, r, or v. Thus **svelto** (*quick*, nimble), pr. *zvel'to.*

SC before **e** and **i** is pronounced like English *sh* in *ship*. Thus **scena** (*scene*), pr. *shay'na*; **scelta** (*choice*), pr. *shel'ta*. Before **-a**, **-o**, **-u**, it is pronounced like *sk*, **scusa.**

SCH is always pronounced like *sch* in *school* or *sk* in *skip*. Thus **schiavo** (*slave*), pr. *skeeah'vo*, almost *skyah'vo*.

Z if not at the beginning of a word is pronounced like *ts* in *bits*. Thus **scienza** (*science*), pr. *sheeaynt'sa*. If at the beginning of a word, it often sounds like *dz* in *adze*: **zelo** (*zeal*), pr. *dzay'lo*; **zero** (*zero*), pr. *dzay'ro*. Learn these two essential words.

ZZ is generally pronounced like *ts* in *bits*: **bellezza** (*beauty*), pr. *bellayt'sa*. Note, however, that it is pronounced like *dz* in the following: **mezzo** (*half*, *middle*), pr. *med'dzo*; **dozzina** (*dozen*), pr. *doddzeen'a*; also in verbs ending **-zzare**. Thus **scandalizzare** (*scandalize*), pr. *scandah-leedzah'rey*; **analizzare**, *analyse*; **fertilizzare**, *to fertilize*. Learn these words, especially **mezzo** and **dozzina**, as they are essential.

Italian consonants have fixed values, and each consonantal sound is pronounced clearly. The English student is apt to pronounce indistinctly, a tendency which must be avoided. Remember especially to pronounce a double consonant *twice*. Thus **agnello** (*lamb*), pr. *ahnyel'lo*; **fratello** (*brother*), pr. *frahtel'lo*; **fiamma** (*flame*), pr. *fyahm'ma*.

WARNING

The student must realize clearly that **all "imitated" pronunciation and English equivalents** such as those already given are **makeshifts.** Strictly, every Italian letter and combination of letters should be regarded as representing a sound or sounds quite different from anything in English. These makeshift equivalents are a rough and ready guide to Italian pronunciation; they can never adequately take the place of pronunciation taught by a native teacher. The serious student should try to find a native to teach him the elements of pronunciation—it will repay him tenfold, and probably prevent the acquisition at the outset of a faulty Italian accent. A faulty accent so acquired tends to remain; it is *extremely* difficult to eliminate afterwards.

If no native teacher is available, listen to gramophone records of speech or singing, of which many are available. Or listen to broadcasts from Italian stations. Never be afraid to speak to Italians—they are a loquacious race, and will be only too delighted to help. Roll your **r**'s, pronounce your vowels "pure," and give each consonant, and especially double consonants, full value.

Italian pronunciation is easy, but it needs careful attention in the beginning stage; its keynote is clarity and distinctness. Its characteristic when well pronounced is softness and a mellifluous beauty of sound. In this respect it has probably no equal amongst European languages; and therefore the pronunciation is worthy of close attention.

LESSON 2

Definite and Indefinite Articles

THE words *the* and *a* are called articles, the former the definite, the latter the indefinite article.

Definite Article

For *the*, the Italian equivalents are:

il, before a masculine noun **lo**, before a masculine noun beginning with an **s** impure or **z** **la**, before a feminine noun	in the singular
i, before a masculine noun **gli**, before a masculine noun beginning with a vowel, **s** impure or **z** **le**, before a feminine noun	in the plural

Examples

Singular	Plural
il padre, *the father*	**i padri**, *the fathers*
lo stato, *the state*	**gli statim** *the states*
la città, *the city*	**le città**, *the cities*

NOTE.

lo is shortened to **l'** before words beginning with a vowel.

gli may be shortened to **gl'** before words beginning with **i**.

la is shortened to **l'** before words beginning with a vowel.

le is shortened to **l'** only before words beginning with an e.

Example

Masculine	**l'amico** *the friend* **l'italiano** *the Italian*	**gli amici** *the friends* **gl'italiani** *the Italians*
Feminine	**l'ambizione** *the ambition* **l'erba** *the grass*	**le ambizioni** *the ambitions* **l'erbe** *the grasses*

When the definite article occurs with certain prepositions, the article and preposition are combined to form a contraction. Thus, instead of writing **a** (*to*) **il** (*the*), one writes **al.**

And instead of **da il** (*from*, or *by the*), one says and writes **dal**, etc.

Contraction is of frequent occurrence in Italian—it is used in the interest of euphony—and the student must become familiar with it at an early stage. Hence, although the following table is given here for reference, and need not necessarily be mastered now, **the sooner it is memorised the better.**

The prepositions which form contractions with the article are:

A, *to, at*; **CON**, *with*; **DA**, *by, from*; **DI**, *of*; **IN**, *in*; **PER**, *for, by*; **SU**, *on*.

	il	lo	l'	la	i	gli	le
A	al	allo	all'	alla	ai	agli	alle
CON	col	(collo)	coll'	colla	coi	(cogli)	(colle)
DA	dal	dallo	dall'	dalla	dai	dagli	dalle
DI	del	dello	dell'	della	dei	degli	delle
IN	nel	nello	nell'	nella	nei	negli	nelle
PER	pel	(pello)	pell'	(pella)	(pei)	(pegli)	(pelle)
SU	sul	sullo	sull'	sulla	sui	sugli	sulle

Translation of "Some" or "Any"

The preposition **DI** combined with the definite article expresses *some* or *any*. Thus:

DEL VINO means *some wine*.
DEI LIBRI means *some books*.

Voglio bere di questa birra, *I wish to drink some of this beer.*

Usage which Differs from English

The article is used in Italian:

(*a*) For the hour: **Che ora è?** *What o'clock is it?* **E l'una.** *It is one o'clock. Two o'clock:* **le due.** (The words **ora, ore,** meaning *hour-s*, are understood after **una** and **due.**) *It is a quarter past eleven:* **Sono le undici ed[1] un quarto.** Literally. *They are the eleven (hours) and a quarter.*

(*b*) For the date: **Quanti ne abbiamo del mese?** *What day of the month is it?* **Ne abbiamo dieci.** *It is the tenth.* **Il 25 di Gennaio, del 1958.** (On) *the 25th January*, 1958.

(*c*) Before titles and Signore, Signora, Signorina *Duke Peter*: **Il duca Pietro.** *Mr. X has arrived from London*: **Il signor X è arrivato da Londra.** *Mrs. Jones is here*. **La signora Jones è qui.**

(*d*) Before names of countries. **L'Italia**, *Italy*. **L'Inghilterra**, *England*. **La Francia**, *France*.

(NOTE. **In Francia**, *in France*, but **Nella Gran Bretagna**, *in Great Britain*).

(*e*) The article is repeated before several nouns in Italian. Thus: **io ho comprato l'inchiostro, la carta ed il libro**, *I have bought the ink, paper, and book*.

(*f*) To express 'a' in such phrases as *Five francs a pound, Three times a week*: **Cinque franchi la libbra; tre volte la settimana.**

(*g*) When a noun is used in a general sense or to the fullest extent of its meaning: **L'uomo è mortale**, *Man is mortal.* **I cavalli sono utili**, *Horses are useful.*

(*h*) To express the possessive case the article is combined with the preposition **DI** (*of*). Thus *The mother's secret* becomes *The secret of the mother*: **Il segreto della madre.**

[1] **Ed** is used for **e** (*and*) before a vowel.

The Indefinite Article

There are four forms in Italian equivalent to *a* or *an* in English.

UN before a masculine noun.
UNO before S impure or Z.
UNA before a feminine noun.
UN' before a feminine noun beginning with a vowel.

Examples:

UN LAGO, *a lake*
UNO ZIO, *an uncle.*
UNA FIGLIA, *a daughter.*
UN'ORA, *an hour.*

Generally the indefinite article is used in Italian as in English, but note the following:

OMIT THE ARTICLE: (*a*) When stating a nationality, rank, profession, or trade:

io sono tedesco: *I am a German.*
io sono capitano: *I am a captain.*
E artista: *He is an artist.*
E sarto: *He is a tailor.*

(*b*) before a noun in apposition:

Vittorio Emanuele, re d'Italia: *Vittorio Emanuele,* (the) *King of Italy.*

NOTE: **a casa**, *at home*; **a scuola**, *at school*, **in camera**, *in the room*; **du cucina**, *of the kitchen*; **com amore**, *lovingly*. **Gli** (and never **i**) is used before the plural word "gods." Thus: **Gli dei**– *the gods.*

EXERCISE

Use of the Articles and Their Contractions

Il cane è compagno fedele dell' (di-l') uomo.
The dog is the faithful companion of man.
Lo studio delle (di-le) lingue è interessante.
The study of languages is interesting.
L'amico di mio fratello è francese.
The friend of my brother is French.
La città di Londra è grande e molto bella.
The city of London is big and very beautiful.
I vasi di terracotta sono fragili.
Vases in terracotta are fragile.
Gli zii sono arrivati questa mattina.
The uncles arrived this morning.
Le tazze ed i piatti sono gialli.
The cups and the plates are yellow.
L'erba è verde.
Grass is green.
Gli insetti sono noiosi in estate.
Insects are tiresome in summer.

Definite Articles Contracted with Prepositions

AL (a-il) segretario fu data la responsabilità.
To the secretary was given the responsibility.
DALLA (da-la) cupola di S. Pietro si vede tutta Roma.
From the dome of St. Peter's one can see the whole of Rome.
DAI (da-i) buoni pensieri nascono le buone azioni.
From good thoughts good factions are born.
DAGLI (da-gli) storici ci vengono raccontati gli eventi che ebbero luogo nei tempi passati.
By the historians we are told of the events which took place in times gone by.
DALLE (da-le) prime ore del mattino si conosce il buon giorno.
From the first hours of the morning we can tell what the day will be.
SUL (su-il) mare veleggiano delle barche pesche-recce.
On the sea some fishing boats sail.

Translation of "Some" and "Any"

Mi dia vino bianco.
Give me some white wine.
Vuole dei libri di lettura?
Do you want any reading books?
No, mi dia invece dei piccoli raccontini.
No, give me some short stories.

Usage which Differs from English

Devo essere a casa all'una.
I must be home by one.
COL (con-il) fiore in mano essa passò oltre.
With the flower in her hand she passed on.
DAL (da-il) carro saltò a terra.
From the cart he jumped to the ground.
Il mistero DEL (di-il) sonno non è stato ancora spiegato.
The mystery of sleep has not yet been explained.
NEL (in-il) salotto troverà il libro verde.
In the lounge you will find the green book.

SUL (su-il) piazzale c'è il venditore di giornali.
On the square there is the newspaper seller.

ALLO (a-lo) spuntar del giorno il sole illumina i sette colli di Roma.
At the break of day the sun illuminates the seven hills of Rome.

ALLA (a-la) mattina presto cominciano a cantare i galli.
Early in the morning the cocks begin to crow.

AI (a-i) laghi vanno molti in estate.
To the lakes go many in summer.

ALLE (a-le) alunne della scuola italiana fu data una vacanza.
To the girls of the Italian school was given a holiday.

COLL' (con-l') amore non si deve scherzare.
With love one should not play.

COI (con-i) pesci nel lago si trovava una ranocchia.
With the fishes in the lake there was a frog.

COGLI (con-gli) amici bisogna esser sinceri.
With friends one must be sincere.

A che ora parte per Napoli ?
At what time do you leave for Naples ?

Quando sono le undici dovrò cominciare a prepararmi.
When it is eleven I shall have to begin to get ready

Quanti ne abbiamo oggi ?
What is the date to-day ?

È il 28 Aprile.
It is the 28th of April.

Il Signor, la Signora e la Signorina Birilli sono arrivat ieri sera.
Mr., Mrs., and Miss Birilli arrived yesterday evening.

Ho comprato il cotone e gli aghi.
I bought cotton and needles.

L'Italia è un bel paese e merita di essere visitata.
Italy is a beautiful country and deserves to be visited.

The Indefinite Article

Un uomo è passato proprio adesso per la strada.
A man has just gone down the street.

Uno scolaro diligente lavora parecchie ore al giorno.
A diligent scholar works several hours a day.

È una cosa piacevole il viaggiare all'estero.
It is a pleasant thing to travel abroad.

Ci vuole un'ora per arrivare in città.
It takes an hour to get to town.

Omission of the Article

Io sono italiano, mia madre è inglese ed i miei fratelli sono irlandesi.
I am Italian, my mother is English, and my brothers are Irish.

Egli è artista ed è ben conosciuto in questa città.
He is an artist and he is well known in this town.

NOTE. **Mia madre è a casa, mia sorella è a scuola ; tutte e due lavorano con piacere.**

My mother is at home ; my sister is at school ; both work with pleasure.

LESSON 3

Genders and Numbers of Nouns

A NOUN is a word used for naming some *person* or *thing*.

There are two genders for Italian nouns : masculine and feminine.

(1) The names of men and male animals are masculine ; the names of women and female animals are feminine.

(2) Nouns ending in **-o** or a consonant are masculine, and nouns ending in **-a**, **-ione**, or **-u** are feminine :

il padre, *the father*	**la madre**, *the mother*
il giuoco, *the game*	**la casa**, *the house*
la colazione, *the meal*	**la virtù**, *virtue*

Note the following : **la mano (plur. le mani)** *the hand*, **muro** (masc.) *wall*, plur. **i muri** means *walls of a room* and plural **le mura** (fem.) means *external walls ;* **paio** (masc.) *pair*, plur. **paia** (fem.) ; **riso** (masc.) *laugh*, plur. **risa** (fem.) ; **centinaio** (masc.) *hundred*, plur. **centinaia** (fem.) ; **migliaio**, (masc.) *a thousand*, plur. **migliaia** ; **miglio** (masc.) *mile*, plur. **miglia** (fem.).

Apart from the above simple rules, which cover the majority of Italian nouns, the student is advised to learn the gender of each noun as it is met.

Many masculine nouns may be made feminine by changing the ending **-O** into **-A**. Thus :

Ragazzo, *boy*, **ragazza**, *girl* ; **cuoco**, *cook* (m.), **cuoca**, *cook* (fem.) ; **cittadino**, *citizen* (m.), **cittadina**, *citizen* **(fem)**.

This is a most useful rule—one which doubles a whole section of one's vocabulary.

There are five simple rules for the formation of the plural of Italian nouns :

1. Nouns ending in a vowel, excepting feminine nouns ending in **-a**, change the final vowel into **-i** :

il poeta, *the poet*	**i poeti**, *poets*
la madre, *the mother*	**le madri**, *mothers*
il padre, *the father*	**i padri**, *fathers*

2. Feminine nouns ending in **-a** change this to **-e** :

la ragazza, *the girl*	**le ragazze**, *girls*
la porta, *door*	**le porte**, *doors*
l'ora, *hour*	**le ore**, *hours*

3. Nouns ending in **-io**, omit the **-o** in the plural :

il figlio, *the son*	**i figli**, *the sons*

But if the **i** is accented as **lo zio**, *the uncle*, then the -o is changed to -i. Thus : **gli zii**, *the uncles*.

The endings -io, -ia usually make one syllable : the **i** is rarely accented. This helps to explain why **figlio** has the stress on the i, and why the plural is **figli** and not **figlii**.

NOTE. Nouns ending in **-ca, -ga, -co, -go**, besides changing the **a** and **o**, add **h** after the **c** or **g** to preserve euphony :

il duca, *the duke*	**i duchi**, *dukes*
il collega, *the colleague*	**i colleghi**, *colleagues*
il fico, *the fig*	**i fichi**, *figs*
il lago, *the lake*	**i laghi**, *lakes*

NOTE ALSO—

il porco, *pig*	**i porci**, *pigs*
l'amico, *friend*	**gli amici**, *friends*
il Greco, *the Greek*	**i Greci**, *Greeks*
médico, *doctor*	**médici**, *doctors*
critico, *critic*	**critici**, *critics*

4. Most nouns ending in **-cia** or **-gia** omit the **i** in the plural :

la pioggia, *rain*	**e piogge**, *rains*
la provincia, *province*	**le province**, *province*

5. Words ending in a consonant or stressed vowel do not change in the plural :

il re, *the king*	**i re,** *the kings*
la difficoltà, *difficulty*	**le difficoltà,** *difficulties*

Irregular Plurals

Singular	Plural
ALA (f.), *wing*	ALI, *wings*
BUE, *ox*	BUOI, *oxen*
DIO, *God*	DEI, *gods*
MILLE, *thousand*	MILA, *thousands*
UOMO, *man*	UOMINI, *men*

NOTE. **Le fórbici,** *scissors* (no singular).

You should now begin to learn nouns from the Alphabetical List given in Lesson 10.

As your studies continue through adjectives, pronouns, and verbs, you will learn these words in the lessons and from the list.

Start a note book. Copy into it not fewer than ten words every day and learn them until you know them.

In the exercises which follow, the English equivalent is given, so you are saved the trouble of looking up every word.

At first be content to follow the meaning of the Italian text. On second perusal, you must know it exactly and the grammatical reasons for the various inflexions.

EXERCISE ON NOUNS
Gender

Il giardino dell'artista è grande e ben tenuto.
The artist's garden is large and well kept.

La madre del capitano ha delle belle mani.
The captain's mother has beautiful hands.

La pazienza è una delle prima virtù.
Patience is one of the first virtues.

La Maria si è comprato due paia di scarpe.
Mary has bought herself two pairs of shoes.

Le uova fresche sono buone per la salute.
New-laid eggs are good for the health

Exceptions

Mia cugina si è fatta male alla mano.
My cousin has hurt her hand.

Le armi da fuoco sono pericolose.
Firearms are dangerous.

Gente allegra il ciel l'aiuta.
Heaven helps merry people.

La mente è prima, l'azione seconda.
Mind is first, action second.

La canzone che cantava mia madre era bellissima.
The song my mother used to sing was very beautiful.

L'ape ci dà il miele e la cera.
The bee gives us honey and wax.

Il poeta Dante Alighieri scrisse la Divina Commedia, il poema più grande della letteratura italiana.
The poet Dante Alighieri wrote the Divine Comedy, the greatest poem of Italian literature.

I quattro più grandi poeti italiani sono : Dante, Petrarca, Tasso ed Ariosto.
The four greatest Italian poets are . Dante, Petrarch, Tasso, and Ariosto

Il muraglione intorno al giardino è molto alto.
The wall round the garden is very high.

Il piccione fa molte miglia al volo e spesso arriva esausto.
The pigeon covers many miles in flight and often arrives exhausted.

Questo panorama è un poema da per sè stesso.
This panorama is a poem in itself

Plural of Nouns

I figli dello zio Carlo sono molto intelligenti, ma i figli degli zii Andrea e Giovanni sono molto pigri.
The sons of uncle Charles are very intelligent, but the sons of uncles Andrew and John are very lazy.

Le ragazze che vidi ieri sera sono amiche di mia figlia.
The girls I saw last evening are friends of my daughter.

I laghi della Scozia sono molto rinomati ed attraggono molti visitatori nell'estate.
The lakes of Scotland are very renowned and attract many visitors in summer.

I fichi che ho comprati ieri mattina sono ben maturi.
The figs I bought yesterday morning are quite ripe.

LESSON 4

Adjectives and Numerals

An adjective is a word used to describe the quality of a noun. In Italian the adjective agrees in gender and number with the noun, and usually follows it. This rule applies wherever there is one or more adjectives qualifying the noun.

(The student who knows French will appreciate as he advances in Italian that the position of adjectives is often determined by taste, but for the present he should keep to the rule just given.)

Most adjectives end in **-o** in the masculine and **-a** in the feminine, but those ending in **-e** do not change in the feminine. Thus :

nuovo, *new* (masc.).
nuova, *new* (fem.).
diligente, *diligent* (masc. and fem.).

The plural of adjectives is formed according to the same rules as the plural of nouns (see p. 1814). Thus :

nuovo, nuovi ; *new*, masc., sing. and plur.
nuova, nuove ; *new*, fem., sing. and plur.
diligente, diligenti ; *diligent*, (masc., fem., sing. and plur.).

Euphonic changes :

bianco, *white* (masc.), plur **bianchi** (masc.), **bianche** (fem.).
lungo, *long* (masc.), plur. **lunghi, lunghe.**
tedesco, *German* (masc.), plur. **tedeschi, tedesche.**

Adjectives ending in **-io** drop the **o** in the plural :

savio, *wise*, pl. **savi** (fem. plur. **savie**).

Adjectives which Precede the Noun : Important. The following seven adjectives are placed before their nouns :

bello, *beautiful*	**brutto,** *ugly*
buono, *good*	**cattivo,** *bad*
grande, *big, great*	**piccolo,** *small*
santo, *saint*	

Bello, buono, grande, and **santo** are usually abbreviated (but never before **z** or **s** impure) in the masculine singular, as follows :

bel, buon, gran, san, before a consonant.
bell', buon', grand', sant' before a vowel.

The plural of **bel** is **bei.**

" " " **bello** } is **belli** (**begli** before
" " " **bell'** } a vowel or s impure, **begl'** before **i**).

Comparison

Superiority :	(1)	(2)	(3)
	più	(adjective)	**di** or **che**
	più	**bello**	**di**
	more	*beautiful*	*than*
Inferiority :	**meno**	(adjective)	**di** *or* **che**
	meno	**bello**	**di**
	less	*beautiful*	*than*

Than is translated by either **di** or **che** :

(a) by **di** before a noun, pronoun or number
(b) by **che** before an adjective, verb or adverb.

Thus : **Lo zio è più ricco del fratello,** *The uncle is richer than the brother.* **Egli ha più di tre sorelle,** *He has more than three sisters.* But : **Méglio tardi che mai,** *Better late than never.*

Equality :	(1)	(2)	(3)
	così	(adjective)	**come**
	così	**bello**	**come**
	as	*beautiful*	*as*

The Superlative

The superlative is formed by placing the article before the comparative :

il più ricco, *the richest* (masc.)
la più cattiva, *the worst* (fem.)
il meno brutto, *the least ugly* (masc.)
la meno bella, *the least beautiful* (fem.)

The word **molto** (*much, very*) is frequently used to form a sort of superlative : **È molto ricco,** *he is very* (i.e. superlatively) *rich.*

Another common superlative (in speech though not in writing) is formed by repeating the adjective.

L'inglese è difficile, difficile, *English is difficult, most difficult.* **Piano piano,** *very softly.*

And there is the "superlative absolute," formed by dropping the last vowel of an adjective and adding **-issimo.**

bravo, *brave*	**bravissimo,** *most brave*
ricco, *rich*	**ricchissimo,** *most rich*

Note the change in spelling **ricchissimo,** for euphony.

Also in the comparative and superlative, the adjective usually follows the noun :

La città più bella, *The most beautiful city.*
I metalli utilíssimi agli uómini, *The most useful metals for men.*

Irregular Comparatives and Superlatives

Positive	Comp.	Sup
alto,	**superiore,**	**supremo,**
high	higher	highest
buono,	**migliore,**	**il migliore,**
good	better	best
cattivo,	**peggiore,**	**il peggiore,**
bad	worse	worst
grande.	**maggiore,**	**ill maggiore,**
big	bigger	biggest
piccolo,	**minore,**	**il minore,**
small	smaller	smallest

The above have also regular forms : **più alto, il piu alto, etc.**

Miscellaneous

As much . . . as : **tanto . . . quanto.**

Egli è tanto allegro quanto suo figlio, *He is as happy as his son.*

Io ho tanti libri quanto lei, *I have as many books as you.*

Tale . . . quale : *just as . . ., in such condition as.*

Le penne tali quali le ho ricevute, *The pens just as I received them.*

At this point the student should begin to learn adjectives from the list in Lesson 10.

NUMBERS

Cardinals

1	**un** / **uno, a.**[1]	30	**trenta**
		31	**trentuno**
2	**due**	32	**trentadue**
3	**tre**	33	**trentatrè, etc.**
4	**quattro**	40	**quaranta**
5	**cinque**	50	**cinquanta**
6	**sei.**	60	**sessanta**
7	**sette**	70	**settanta**
8	**otto**	80	**ottanta**
9	**nove**	90	**novanta**
10	**dieci**	100	**cento**
11	**ùndici**	101	**centuno**
12	**dódici**	102	**centodue**
13	**trédici**	200	**duecento**
14	**quattórdici**	300	**trecento**
15	**quindici**	400	**quattrocento**
16	**sédici**	500	**cinquecento**
17	**diciassette**	600	**seicento**
18	**diciotto**	700	**settecento**
19	**diciannove**	800	**ottocento**
20	**venti**	900	**novecento**
21	**ventuno**	1000	**mille**
22	**ventidue**	2000	**duemila**
23	**ventitré etc.**	*One million,*	**un milione**

Ordinals

1st	**primo, a**	6th	**sesto, a**
2nd	**secondo, a**	7th	**séttimo, a**
3rd	**terzo, a**	8th	**ottavo, a**
4th	**quarto, a**	9th	**nono, a**
5th	**quinto, a**	10th	**décimo, a**

Use of Numerals. Una ; drops the last letter when the *next* word begins with a vowel : **un' amica,** *a (or one) friend* ; **un'áncora,** *an anchor.* Use **uno** before s impure or z.

Uno, una, otto : when used to form compounds cause the *other* numbers to drop their final vowel : Thus : **ventuno, -a, centuno, -a, ventotto.**

Cento has no feminine or plural, and in Tuscan drops the **-to** when preceding an unstressed syllable : **duecen-quaranta.**

Mille and **milione** have plurals : **mila, milioni.**

On the 5th, 6th : **Ai cinque, ai sei.**

Dates. *London, 15th January,* 1958 : **Londra, il 15 (di) gennaio (di) 1958.** *What is the date?* **Quanti ne abbiamo del mese ?** *It is the 8th :* **Ne abbiamo otto.**

Age : *How old are you?* **Quanti anni ha lei ?** *I am* 25 *years old.* **Io ho 25 anni** (lit. I have 25 years). *A year ago :* **Un anno fa.** *Within six months :* **Fra sei mesi.** *All two, all three, all four :* **Tutti e due, tutti e tre, tutti e quattro.** *Both brothers, both sisters :* **Ambedue i fratelli, ambedue le sorelle.** *Each* is translated by **ogni** (masc. and fem. and sing. only) : **ogni casa,** *every house.*

[1] **Uno** is used in counting or before s impure or z. **Un** is the ordinary masculine form for *one.* Thus : **Un generale,** means either *a general* or *one general*

Miscellaneous—*Learn on Second Perusal*

zero, *zero, nought*
un paio, *a pair, a brace*
una coppia, *a couple*
una dozzina, *a dozen*
una ventina, *a score*
una trentina, *thirty or so*
la metà, *the half*
un terzo, *a third*
un quarto, *a fourth*
il doppio, *the double*
il triplo, *the triple*
una quarantina, 2 *score*
una cinquantina, *half a hundred*
un centinaio, *a hundred or so*
un migliaio, *a thousand or so*
a centinaia, *by hundreds*
a migliaia, *by thousands*
un quinto, *a fifth*
uno ad uno, *one by one*
due a due, *two by two*
il quadruplo, *the quadruple*
un centuplo, *a hundred-fold*
un trimestre, *a term, quarter (three months)*
un triennio, *three years period*
l'último, *the last*

The Time

What time is it? **Che ora è?**
Noon, **Mezzogiorno** (or **mezzodì,** or **le dódici**).
Midnight, **Mezzanotte.**
One o'clock, **L'una** (also: **il tocco**).
Two o'clock, **Le due.**
A quarter past three, **Le tre e un quarto.**
Half past four, **Le quattro e mezzo.**
A quarter to five, **Le quattro e tre quarti** (*four and three quarters*).
Ten minutes to six, **Le sei meno dieci** (*six less ten*).
Five past seven, **Le sette e cinque.**
It is striking one, **Suona l'una.**
It is striking six, **Suónano le sei.**

EXERCISE ON ADJECTIVES AND NUMERALS

Adjectives which Precede the Noun

Una bella ragazza era con mia madre al ballo ieri sera.
A beautiful girl was with my mother last night at the dance (ball).

Un buon consiglio può essere di grande aiuto in certi casi.
(A) good advice may be of great help in some cases.

Che bel giardino!
What a beautiful garden!

Comparison

Il cappello di Enrico è più grande di quello di Giovanni.
Henry's hat is bigger than John's.

Il giardino di Maria è meno bello di quello di Rosa.
Mary's garden is less beautiful than Rose's.

È meglio arrivare presto che essere in ritardo.
It is better to arrive early than to be late.

Essa è così agile come sua sorella.
She is as agile as her sister.

Nel traversare la strada è meglio andar piano che presto.
In crossing the road it is better to go slowly than quickly.

The Superlative

L'agricoltura è la più utile delle arti.
Agriculture is the most useful of arts.

Fra tutte le ragazze che vidi ieri al concerto la Rosina era la meno bella.
Amongst all the girls I saw yesterday at the concert Rosina was the least beautiful.

Quando andai a visitare la scuola mi venne mostrato il peggiore allievo.
When I went to visit the school they showed me the worst pupil.

La lingua inglese è molto difficile per gli italiani, viceversa la lingua italiana è facilissima per gli inglesi.
English is very difficult for Italians, vice versa, Italian is very easy for the English.

Ma lei canta molto bene. Bravo, anzi bravissimo!
But you sing very well. Good, very good!

Non è vero che sia la morte il peggior di tutti i mali; è un sollievo pei mortali che son stanchi di soffrir!
It is not true that death is the worst of ills; it is a rest for those poor mortals who are tired of suffering.

Caruso è stato il celeberrimo tenore di questo secolo.
Caruso has been the most celebrated tenor of this century.

I libri del Basic sono utilissimi per lo studio delle lingue.
The books of Basic are most useful for the study of languages.

Numbers

Una mattina andando a spasso in campagna vidi tre ragazzi che giuocavano con due cagnolini; uno era bianco e l'altro nero.
One morning going for a walk in the country I saw three boys playing with two puppies; one was white and the other black.

Il 3 di luglio è il mio giorno natalizio.
The 3rd of July is my birthday.

Nel milleottocento settanta l'Italia fu unita sotto il regno di Vittorio Emanuele II.
In eighteen hundred and seventy Italy was united under the reign of Victor Emanuel II.

Verrò a vederla il diciotto aprile prossimo.
I shall come to see you on the 18th of April next.

Il cavallo cadde dopo di aver percorso tre quarti di miglio.
The horse fell after it had gone three quarters of a mile.

L'ora si compone di quattro quarti d'ora, sei quarti formano un'ora e mezzo.
The hour is composed of four quarters; six quarters make one hour and a half.

Verso la fine del quindicesimo secolo, nel suo studio a Firenze, Leonardo da Vinci lavorava su innumerevoli cose di una natura la più variata. Egli era scultore, pittore, architetto, ingegnere, chimico ed anatomista.
Towards the end of the fifteenth century in his studio in Florence, Leonardo da Vinci was working on innumerable things of the most varied nature. He was a sculptor, painter, architect, engineer, chemist, and anatomist.

A che ora va a pranzo generalmente? Alle sei di sera, ma non ceno.
At what time do you generally go to dinner? At six o'clock, but I do not have supper.

Non ho mai saputo quanti anni ha lei; ma non credo che abbia più di venticinque anni.
I never knew how many years old you are; but I suppose you are not more than twenty-five.

Suonano le undici, bisogna che io la lasci. Arrivederci!
It is striking eleven, I must leave you. Good-bye!

LESSON 5

Pronouns and Their Uses

A PRONOUN is a word used instead of a noun or a noun equivalent.

Pronouns are dealt with in this Lesson in the natural sequence: Personal, Conjunctive Personal, Reflexive, Relative, Interrogative, Demonstrative, Possessive, Indefinite. There are also notes on Variable and Invariable Pronouns, and some exercises.

In the list on the right the subject pronouns answer the question: who or what *acted?* The direct object pronouns answer the question: who or what was the *primary* recipient of the action? The indirect object pronouns answer the question: who or what was the *indirect* or *secondary* recipient of the action?

Thus in *I will tell it to him*, *I* is the *subject*; *it* is the *direct object*; *him*, is *indirect object*.

Never forget that *every Italian noun is masculine or feminine in gender, and a corresponding gender must be used when it is replaced by a pronoun.*

Thus: **Ecco la mia casa. (essa) è molto bella.**
Here is my house, it is very beautiful.

As the Personal Pronouns (and indeed *all* pronouns) are of frequent occurrence the student must memorise them now. But note:

Egli, ella, églino are used for *persons* but **esso, essa, essi, esse** may be used for persons, animals, or things.

In speaking (but not in literature) **essi** and **esse** are used instead of **églino** and **élleno** (which tend to disappear entirely).

YOU. The English word *you* is translated by LEI, and this is followed by the verb in the Third Person Singular. LEI is used for both masculine and feminine. The plural form of LEI is LORO. The beginner should never use TU or VOI. Thus:

LEI HA, *you have* (sing.).
LORO HANNO, *you have* (plur.).
Parla lei italiano? *Do you speak Italian?*

TU is used to address children, relations, intimate friends, and animals. The foreigner should avoid it until he knows Italian well.

VOI is used in speechmaking or addressing a number of people (soldiers) and in commercial correspondence Avoid it! Use **Lei.**

IT: The word "it" may often be omitted in Italian. **È vero,** *it is true*; **Ha fatto?** *Have you done it?*

SELF: The word "self" may be added to the above pronouns by "**stesso**": **io stesso,** *I myself*; **lei stesso,** *you yourself, yourself, etc.* And in the fem. etc., **io stessa**: **lei stessa.** Plur. **noi stessi, loro stessi.**

SÈ, Itself, third person singular and plural, reflexive, not used in nominative, **se stesso,** *himself.*

PERSONAL PRONOUNS

Subject Pronouns	Object Pronouns		
I		II	III
io, I		**Direct**	**Indirect**
tu, *thou*	1st Pers. Sing	**mi, me,** *me*	**mi, a me,** *to me*
egli, esso, *he* or *it* (masc.).	2nd „ „	**la, la,** *you*	**le, a lei,** *to you*[1]
	„ „	**ti, te,** *thee*	**ti, a te,** *to thee*
ella, essa, *she* or *it* (fem.)	1st „ Plur.	**ci, noi,** *us*	**ci, a noi,** *to us*
	2nd „ „	**vi, voi,** *you*	**vi, a voi,** *to you*
lei, *you* (see this page)	3rd „ Sing.	**lo, lui,** *him*	**gli, a lui,** *to him*
	„ „	**la, lei,** *her*	**le, a lei,** *to her*
noi, *we*	„ „ (m.)	**lo, essa,** *it*	**vi** **ad esso,** *to it*
voi, *you*	„ „ (f.)	**la, essa,** *it*	**ci** **ad essa,** *to it*
églino, essi, *they* (masc.)	„ Plur. (m.)		**loro, a loro,** *to them*
	„ „ (f.)	**li, le,** **loro,** *them*	
élleno, esse, *they* (fem.)			
loro, *they*[1]	„ „ (m.)	**li, essi,** *them*	**vi** **ad essi,** *to them*
	„ „ (f.)	**le, esse,** *them*	**ci** **ad essi,** *to them*
[1]Corresponds to lei, for which see below	Reflexives and p. *himself, herself, itself, themselves*	**si, sè**	**si, a sè**

Conjunctive Personal Pronouns

These are so called because they precede the verb or can be joined with it when they follow. They are:

mi, *me, to me*; **ti,** *thee, to thee*; **lo,** *him, it* (masc.); **gli,** *to him*; **la,** *her*; **le,** *to her*; **ci** or **ne,** *us, to us*; **vi,** *you, to you*; **li** or **gli,** *them, to them* (masc.); **le,** *them, to them* (fem.); **si,** *himself, herself, themselves.*

Vi prego di darmi uno zolfanello, *I pray you to* (i.e. please) *give me a match.* **Crédimi,** *Believe me*; **Chiamàtelo!** *Call him!* **amarla,** *to love her.*

Position of Pronouns

The conjunctive pronouns precede the verb as in the following:

Egli mi dà, *he gives me.*
Io vi vedo, *I see you.*
Lei mi ha dato, *You have given me.*

The Indirect precedes the Direct, when two object pronouns come together:

Me lo dà, *he gives it to me.*
Dateglielo, *give it to him!*

NE follows the direct object;
LORO comes last, following the verb.
Egli ha detto loro, *He has told them.*

ÉCCO: This word means *here is* or *here are* (*voici*, in French). *Here is John,* **Ecco Giovanni.**

Here I am or *behold me*	rendered by	**éccomi**
Here he is or *behold him*		**éccolo**
Here she is or *behold her*		**éccola**
Here we are or *behold us*		**éccoci**
Here are some or *behold some*		**éccone**

Reflexive Pronouns

The words **mi, ti, si, ci, vi, si,** are used as Reflexive Pronouns in the conjugation of Reflexive Verbs.

Io mi lavo, *I wash myself.*
Tu ti lavi, *Thou washest thyself.*
Egli si lava, *He washes himself.*
Noi ci laviamo, *We wash ourselves.*
Voi vi lavate, *You wash yourself, or selves.*
Essi si lavano, *They wash themselves.*

Relative Pronouns

A relative pronoun is one which connects the noun or pronoun to which it refers with the part of the sentence which follows. Thus: *The man whom I know ; The house that Jack built.*

Whom and *that* are relatives.

The English relative pronouns *who, whom, which,* and *that* are nearly always translated by the word **che.**

In Italian the relative is **never** omitted, as it often is in English. Thus:

The letter (which) I wrote to you has not arrived, **La léttera CHE vi ho scritto non è arrivata.**

On a second perusal, learn the following list of relatives :

Masculine singular	Feminine singular
che or **il quale** (*who, which, that*)	**che** or **la quale**
di cui, del quale (*of whom, which, that*)	**di cui, della quale**
a cui, cui, al quale (*to whom, which, that*)	**a cui, cui, alla quale**
che, cui, ill quale (*whom, which*)	**che, cui, la quale**
da cui, dal quale (*from whom, which, etc*)	**da cui, dalla quale**

Plural

Masculine and Feminine:
che, *who, which, that*
di cui, *of whom, which, that*
di cui, *of whom, which, that*
a cui, *to whom, which, that*
cui, *whom, which*
da cui, *from whom*

Masculine Plural	Feminine Plural
i quali	**le quali**
dei quali	**delle quali**
ai quali	**alle quali**
i quali	**le quali**
dai quali	**dalle quali**

The word **chi** is used only for persons and always in the singular—it means *he who, she who,* etc.

Chi piantò la vite fu Noè, *He who planted the vine was Noah.*

Chi parla adesso è mia cugina, *She who speaks now is my cousin* (fem.).

Chi va piano, va sano, *He who goes slowly goes surely.*

Il che, is often used to translate : *The thing which.* For instance : A says *It is very cold today,* and B wishing to reply *That I dislike* or *Cold is something I dislike* might say **Il che non mi piace.**

Interrogatives

Chi ? *Who ?* **Che ?** *What ?* **Di chi ?** *Of whom ?* **Di chi ?** *Of what ?* **A chi ?** *To whom ?* **A che ?** *To what ?* **Chi ?** *Whom ?* **Che ?** *What ?* **Da chi ?** *From whom ?* **Da che ?** *From what ?* **Quale ?** *Which, which one ?* (masc. and fem. sing.). **Quali ?** *Which, which ones ?* (masc. and fem. plur.).

These words are used instead of **CHE** when the meaning is *Which one of two or more ?* as for example :

Qual è il cappello dell'ufficiale ? *Which* (one of all these) *is the officer's hat ?*

Di questi due cavalli quale vuol lei ? *Of these two horses which one do you want ?*

NOTE. Instead of **CHE** one very often says **CHE COSA,** *What thing.* **Che cosa fa ?** *What are you doing ?* Or simply **Cosa,** as in **Cosa vende il bottegaio ?** *What does the shop-keeper sell ?*

Che (and sometimes **quale**) is used to express *What a* as in *What a fine question !* **Che bella domanda !** *What a beautiful girl !* **Che bella ragazza !**

Demonstrative Pronouns

	Singular masc.	Singular fem.	Plural masc.	Plural fem.
THIS :	**questo**	**questa**	**questi**	**queste**
THAT :	**quello**	**quella**	**que(ll)i**	**quelle**

These words always agree in gender and number with the noun which follows them :

Quello è il male : *That is the misfortune.*
Questo è che io ho sentito, *This is what I have heard.*
Quella ragazza, *That girl.*
Quello non mi piace, *That does not please me.*
Quelle ragazze, *Those girls.*

When followed by a verb and a noun, **Questo** and **Quello** take the gender and number of that noun.

Questa è la mia casa, *This is my house.*
Quei sono fratelli, *Those are brothers.*

Note the abbreviations :

stamattina, *this morning* **(questa mattina).**
stasera, *this evening* **(questa sera).**
stanotte, *to-night* **(questa notte).**

Other demonstratives are :

CIÒ, meaning *that* in a very general sense, and with **che :**

CIÒ CHE means *that which.*
I believe that which I see, **Io credo ciò che vedo.**

Possessive Pronouns

The possessive pronouns and the possessive adjectives have the same forms in Italian, which are :

1st pers.	sing.	**mio, mia, miéi, mie,** *my*
2nd ,,	,,	**tuo, tua, tuoi, tue,** *thy*
3rd ,,	,,	**suo, sua, suoi, sue,** *his, her, its* (also *your*)
1st ,,	plur.	**nostro, nostra, nostri, nostre,** *our*
2nd ,,	,,	**vostro, vostra, vostri, vostre,** *your*
3rd ,,	,,	**loro** (for both genders), *their* (also *your*)

—the difference being that the possessive pronouns usually take the definite article before them if they refer to a thing in the singular and not to a person. Thus:

mio fratello, *my brother*
il mio cappello, *my hat*
i miéi cappelli, *my hats*

In the plural the article is used with both persons and things:

I miéi fratelli, *my brothers*, though it is often omitted with persons. **Questi sono miéi fratelli,** *These are my brothers.*

Di lui and **di lei** are used instead of **suo, sua, suoi, sue** when there is any likelihood of ambiguity or misunderstanding—

This book is his and not hers, **Questo libro è di lui e non di lei.**

The possessive pronouns or adjectives may come after their noun, especially in exclamations:

Amico mío! *My friend!*
Carissimo mio! *My* (very) *dear fellow!*
A casa mia, *in my house*; **per conto mio,** *on my account*; **in nome mio,** *in my name*; **da parte mia,** *on my part.*

Che cappello è? *What hat is it?*
Non è il mio, è il suo, *Not mine—yours* (or *his*).
Il piacere è mio, *The pleasure is mine.*

NOTE. **Possessive pronouns and adjectives in Italian agree in gender and number with the object possessed.**

Indefinite and Miscellaneous. A number of useful and frequently recurring words come under this head and must be memorised, though not necessarily on a first perusal of this Course. Except for the "invariables" given below, they must agree in gender and number with their nouns or the nouns whose place they take.

Invariables

OGNI, *each, every*. **ogni giorno,** *every day.*

NIENTE, *nothing*. **Niente è inutile,** *Nothing is useless*

NULLA, *nothing*. **Nulla ci conforta,** *Nothing comforts us.*

QUALCHE, *any* **qualche cosa,** *anything.*

When **niente** and **nulla** follow a verb the word **non** must be placed before the verb:

Non c'è niente, *there is nothing.*

When they are followed by an adjective they take **DI**.

When they are followed by a verb they take **DA**.

Niente di buono, *nothing good*

Niente (or **nulla**) **da dire,** *nothing to say.*

QUALUNQUE: means *any . . . whatever.*

Qualunque casa, *any house whatever.*

PER QUANTO: *however, whatever.*

Per quanto è in mio potere, *whatever is in my power*

Variables

ALTRO-a-i-e, *other, another.*

ALCUNO-a-i-e, *someone, anyone.*

CIASCUNO-a, *each one, every one* (sing. only).

TUTTO-a-i-e, *all, the whole of* (**Tutti,** *everybody*).

N.B. **TUTTO** is also used for *everything.*

NESSUNO-a, *no one.*

OGNUNO-a, *each one every one.*

CERTUNO-a, *a certain one, one.*

TALUNO-a-i-e, *somebody, someone.*

QUALCUNO-a
QUALCHEDUNO-a } *someone, somebody.*

TALE-i, *such a one, such* (**un tale,** *a certain man*).

TUTTO QUANTO, tutta quanta, tutti quanti, tutte quante, *all, the whole* (**Io ho veduto tutti quanti gli uómini**: *I have seen all the men*—i.e. together).

TANTO-a-i-e, *so much,* **QUANTO-a-i-e,** *how much.*

L'UN, L'ALTRO, L'UNA L'ALTRA; GLI UNI GLI ALTRI, LE UNE LE ALTRE, *each one, one another.*

Ci amiamo l'un l'altro, *we love one another.*

Examples:

Ogni città, *each town*, **ogni volta,** *each time*; **ogni dove,** *everywhere*. N.B. **Ognora,** *always*. **Ognuno lo dice,** *Everybody says so* (i.e. it); **ciascuna volta,** *each time*; **Conosce lei alcuno?** *Do you know anybody?* **noi altri Inglesi,** *we English* (nous autres Anglais); **Così fan tutte,** *So all* (women) *do*; **tutti loro,** *all of you*, **Quanto c'è da pagare?** *How much is to be paid?* **È tutt'altra cosa,** *It is quite another matter*; **tutt'altro,** *on the contrary*, **Il signor tale mi disse,** *Mr. So-and-so told me*, **il tal libro,** *such a book.*

NOTE ALSO: **AMBE,** *both*, plur. **ambi.**

PARECCHI, PARECCHIE (masc. and fem. plur. only) *several.*

PIÙ D'UN, *more than one, many a.*

UN TANTO LA SETTIMANA, *so much a week*

QUANTO PRIMA, *as soon* (early) *as possible.*

QUANTO C'È da Roma a Parigi? *How far is it from Rome to Paris?*

TABLE FOR REFERENCE

some, a certain, one	*each, every*	*anybody*
uno **un certo** **un tale** **certuno** **taluno**	**ogni*** **ognuno** **ciascuno** **tutto**	**alcuno** **qualcuno** **qualche*** **qualcheduno**
who } *ever* *what* *how*	*no one* *none* *nobody*	*other* *another*
qualunque*	**nullo** **nulla*** **niente*** **nessuno**	**altro**

*Invariable, the remainder variable

NOTE. The words in this table are of frequent recurrence and must be known.

The Word SI. The word **si** presents some difficulties which may conveniently be treated here. It has the following meanings:

(1) *Yes.*

(2) *So, so much, as much.*

(3) *Oneself* (reflexive pronoun).

(4) Indefinite pronoun meaning *people, one, they* (French *on*).

(5) to form the passive of verbs.

Examples:

(1) **Parla lei inglese? Sì signore,** *Do you speak English? Yes, sir.*

(2) **Ella canta sì dolcemente,** *She sings so sweetly.* **Sì nella religione che nella politica,** *as much in religion as in politics.*

(3) **Egli si lava,** *He washes himself.*

(4) **Si mangia quando si ha fame,** *One eats when one is hungry.*

(5) **Se si sa, non si dice,** *If it is known, it is not said.*

AND NOTE. **SE** means *if* and **Si** is also the conjunctive pronoun.

EXERCISE ON PRONOUNS

Personal Subject Pronouns

Io imparo l'italiano e lei il tedesco.
I learn Italian and you German.

Egli è venuto alle cinque invece delle quattro.
He came at five instead of four.

Mi dispiace che lei non si senta molto bene questa mattina per andare a fare la sua solita passeggiata al Pincio, le consiglierei di prendere un'automobile e farsi condurre a visitare i musei del Vaticano ; essi sono molto interessanti.

I am sorry that this morning you do not feel well (enough) to go for your usual walk to the Pincio ; I would advise you to take a taxi and go to visit the museums of the Vatican ; they are very interesting.

Object Pronouns

Mi sembra che la sua suggestione sia buona e se le è possibile, sarei molto felice di avere la sua compagnia. Ci faremo portare fino al Castel S. Angelo e poi potremo camminare a piedi alla Piazza di S. Pietro. Visiteremo la Cappella Sistina e se avremo tempo saliremo sulla cupola.

I think your suggestion is good and if you can I should be pleased to have your company We shall drive up to Castel S. Angelo and from there we shall walk to the St. Peter's Square We shall visit the Sistine Chapel and if we (shall) have time we shall go up the dome.

Io mi alzo alle nove e voi invece non vi alzate prima delle 10.

I get up at nine and you on the other hand (instead) do not get up before 10.

Vi prego di far silenzio altrimenti non capirete quel che vi sto spiegando ; è possibile che non possiate star mai fermi? State buoni ragazzi ! Adesso è ora di studiare ; giuocherete quando la scuola è finita.

Please be silent otherwise you will not understand what I am explaining to you ; is it possible that you can never keep still ? Be good children ! Now it is time to study and you will play when the school is finished

Ecco la mia casa, io stesso l'ho fatta fabbricare l'anno scorso, i miei figli si occupano di tenere in ordine il giardino ; a loro ne ho data la responsabilità.

Here is my house, I had it built myself last year, my sons keep the garden in order, to them I gave the responsibility.

Relative Pronouns

L'amico che venne a vedermi qui a Roma tempo fa, mi ha scritto una lunga lettera ; vuole che io vada a trovarlo a Londra durante le mie vacanze.

The friend who came to see me here in Rome some time ago has written to me a long letter ; he wishes me to go and see him in London during my holidays.

Chi va piano va sano e va lontano.
He who goes slowly goes surely and goes farthest.

Chi suona il piano adesso? È mia cugina.
Who is playing the piano now ? It is my cousin.

Demonstrative Pronouns

Quella ragazza che lei vide ieri sera al concerto è mia figlia ; stasera vi andrà di nuovo.

That girl you saw last night at the concert is my daughter, to-night she will go there again.

– **Lei sa che mio figlio ha perduto ultimamente in speculazioni di Borsa e quindi la prego di aspettare ancora tre mesi per la somma che le deve.**

– You know that my son has lost lately in speculations on the Exchange, please wait another three months for the repayment of the amount he owes to you.

—**Ciò non mi riguarda ; esigo che la somma mi venga rimborsata subito, lei ne è responsabile e quindi se lui non paga lei dovrà pagarmi.**

—That has nothing to do with me, I expect to be paid at once ; you are responsible and if he cannot pay me you will have to do so.

Possessive Pronouns

– **Di chi è questo cappello che ho trovato in giardino?**
– Whose hat is this which I found in the garden ?

—**È mio ; grazie !**
It is mine ; thank you !

—**Veramente credevo che fosse di lui.**
—Truly I thought it was his.

Invariable Pronouns

Qualunque sia il caso non mi è possibile di soddisfarla ; ogni volta che viene qui a vedermi ha sempre qualche cosa da domandarmi.

Whatever is the case I cannot satisfy you ; every time you come to see me you ask me for something.

Per quanto io faccia non riesco a capire il senso di questa frase.

Whatever I do I cannot succeed in understanding this phrase.

Non c'è niente di buono al mercato oggi.
There is nothing good in the market to-day.

Variable Pronouns

Ho venduto tutto quel che possedevo, nessuno ha voluto aiutarmi nella mia sfortuna.

I have sold all I had, nobody wished to help me in my misfortune.

Qualcuno potrebbe venire a vedermi oggi e quindi sarà meglio che non esca di casa.

Someone might come to see me to-day and therefore it will be better not to go out of the house.

Ecco una bellissima giornata ; parecchi di loro dovrebbero andare a visitare il Colosseo, il Palatino, il Campidoglio ed il Foro Romano ; ognuno potrebbe portarsi con sè qualche cosa da mangiare e ritornare per il pranzo. Se qualcuno fosse stanco potrebbe riposarsi nel Museo Capitolino ed aspettare gli altri.

This is a beautiful day ; many of you ought to go and visit the Colosseum, the Palatine, the Campidoglio, and the Roman Forum ; everyone could take with him something to eat and come back for dinner. If someone was tired he could rest in the Capitoline Museum and wait for the others.

Quanto prima comincerò il mio libro ; ognuno fa quel che può.

As soon as possible I will begin my book, everyone does what he can.

Per il loro alloggio ed il loro vitto dovranno pagarmi un tanto alla settimana.

For their board and lodging you will have to pay me so much a week.

LESSON 6

Regular and Auxiliary Verbs

A VERB is a word used for saying something about some person or thing.

Compared with the verbs of some languages those of Italian are straightforward. The student may gain assurance from the knowledge that in Italian—

(*a*) He need not learn all the parts of even regular verbs —unless he wishes to become an expert translator, or until he has a working acquaintance with the language.

(*b*) The essential verbs of the first conjugation (ending -**are**) are very numerous, and are *all regular except four*, these four being easy to learn and very useful.

(*c*) The irregular verbs of most frequent occurrence number fewer than 100 and of these it is necessary to learn only the most useful tenses, as given in the following pages.

The treatment of the verb here is highly simplified, and the student must realize from the outset that (unless otherwise noted) he cannot afford to neglect any of it.

The best way to learn the verbs is first to read through these pages a few times in order to grasp the general principles. When the principles are understood, then *E*SSERE and AV*E*RE must be learnt thoroughly; then the "models" for the regular conjugations; then the irregular verbs.

NOTE. As in other sections irregularly stressed vowels are printed in special type. The stressed vowel is indicated either as a capital or by italics.

Parts of the Verb which must be known

(*a*) **The Infinitive**, i.e. that part of a verb which names the action, without reference to any doer, and is therefore not limited by person, number, or time. Thus: **PORTARE**, *to carry* or *bring*, **CR*E*DERE**, *to believe*; **DORMIRE**, *to sleep*; **FINIRE**, *to finish*.

(*b*) **The Present Tense**, which represents the English forms "I —," "I do —," "I am —ing." Thus the word **PORTO**, the Present Tense of **portare**, means *I carry, I do carry*, or *I am carrying*.

(*c*) **The Imperfect Tense**, which is used for a continuous or habitually repeated action in the past; or for an action which is contemporaneous with another action. Thus: **PORTAVO** means, *I carried, I was carrying, I used to carry*.

(*d*) **The Past Definite**, which, as its name indicates, represents a past action which has been completely ended and has no reference to any other action. Thus **PORTAI** means *I carried* (*I did carry*), as in the sentence *I carried the cup out of the dining-room* (and placed it on the kitchen table).

(*e*) **The Future Tense**, which corresponds exactly to the English "I shall —." Thus: *I shall carry*, **PORTERÒ**.

(*f*) **The Past Participle**, which usually corresponds to the similar part of speech in English ending in -ed or -t, and is used with an auxiliary verb to form compound tenses, of which the most frequently recurring in Italian is generally called the "Perfect." Thus: **Io ho portato**, *I have carried* (**PORTATO** is the Past Participle).

General Rule for Conjugation. All verbs ending in **-are** are conjugated like **portare**: all verbs ending in **-ere** are conjugated like **cr*e*dere**: all verbs ending in **-ire** are conjugated like either **dormire** or **finire**. Those which do not follow the models of these four verbs (see below) are called irregular. Their essential parts will be found below.

Formation of Tenses

For purposes of reference a complete table of the inflexions of regular verbs is given opposite. Every part of a regular verb can be formed from this table, but there are certain principles of tense-formation which should be known.

(1) When the *Infinitive* ending **-ARE**, **-ERE**, or **-IRE** is dropped, the part remaining is called the *stem*. Thus:

PORT-	is the stem of	**PORTARE**
CR*E*D-	" " " "	**CR*E*DERE**
DORM-	" " " "	**DORMIRE**
FIN-	" " " "	**FINIRE**

It is to this stem that the endings given in the table in page 1823 are added to form the various tenses.

(2) The *Present Indicative* is formed by adding the following endings to the stem:

	Singular		
	1st Person	2nd Person	3rd Person
Verbs in -ARE	-O	-I	-A
" " -ERE	-O	-I	-E
" " -IRE	-O	-I	-E
	(-isc)O	(-isc)I	(-isc)E
	Plural		
	1st Person	2nd Person	3rd Person
Verbs in -ARE	-IAMO	-ATE	-ANO
" " -ERE	-IAMO	-ETE	-ONO
" " -IRE	-IAMO	-ITE	-ONO
	-IAMO	-ITE	(-isc)ONO

(3) The *Imperfect* tense of all regular verbs is formed by adding the following endings to the stem:

A(E, I) -VO -VI -VA -VAMO -VATE -VANO

N.B. The Imperfect tense is very rarely irregular.

(4) The *Past Definite* is formed by adding to the stem, the endings:

Verbs in
-ARE: -AI -ASTI -Ò -AMMO -ASTE -*A*RONO
-ERE: -EI -ESTI -È -EMMO -ESTE -*E*RONO
-IRE: -II ISTI -Ì -IMMO -ISTE -*I*RONO

(5) The *Future Tense* of all regular verbs is formed by adding to the infinitive from which -E has been dropped, the following:

-Ò -AI -À -EMO -ETE -ANNO

and the **-AR** is changed into **-er**. Thus: **parlare,** *to speak*. **Fut.**: **parlerò.**

(6) The *Conditional* tense is formed by adding to the infinitive from which **-E** has been dropped the following (again changing **-ar** into **-er**):

-EI -ESTI -EBBE -EMMO -ESTE -EBBERO

It will be observed that (excepting the first) these endings are the Past Definite of Avere.

(7) The polite form of the *Imperative* is always the Third Person of the Present Subjunctive and ends as follows:

Verbs in **-ARE**:	**-I** (singular)	**-INO** (plural)
„ „ **-ERE**:	**-A**	**-ANO**
„ „ **-IRE**:	**-A**	**-ANO**
„ „ **-IRE**:	**(isc)A**	**(-isc)ANO**

The endings of Italian verbs indicate the person and number so clearly that pronouns may generally be omitted. But pronouns should always be used for emphasis or to avoid ambiguity. Thus: **Porto,** *I carry*. **Portai,** *I carried*. **Io porto,** *It is I who carry*.

What the Various Italian Tenses Represent in English

Let us take the regular verb **PARLARE,** *to speak*, conjugated exactly like **PORTARE,** and, in the first person of each tense, the translation would be:

Infinitive	**PARLARE,** *to speak*.
Pres. Part.	**parlando,** *speaking*.
Past Part.	**parlato,** *spoken*
Indicative	
Present	**parlo,** *I speak, I am speaking, I do speak*.
Imperfect	**parlavo,** *I spoke* (was speaking), (also, I used to speak).
Past Def.	**parlai,** *I spoke* (once, on one occasion); *did speak*.
Future	**parlerò,** *I shall speak*.
Conditional	**parlerei,** *I should speak*.
Imperative	
	parla, *speak thou*; **parli,** *let him speak* (also polite, speak you).
Subjunctive	
Present	**che io parli,** *that I speak*.
Imperfect	**che io parlassi,** *that I spoke* (**Se io parlassi,** *if I spoke*).
Compound Tense	
Perfect	**ho parlato,** *I have spoken*.
1st Pluperf.	**avevo parlato,** *I had spoken* (been speaking).
2nd Pluperf.	**ebbi parlato,** *I had spoken*.
Future Perf.	**avrò parlato,** *I shall have spoken*.
Past Conditional	**avrei parlato,** *I should have spoken*.
And similarly, *Subjunctive compound tenses*:	
Perfect	**ch'io abbia parlato,** *that I have spoken*.
Pluperfect	**ch'io (se io) avessi parlato,** *that* (if) *I had spoken*, or, *had I spoken*.

NOTE.—For the auxiliary **AVERE** used in forming these compound tenses, see table on next page.

Neither the table of inflexions nor the above need be memorised at this stage. The somewhat extended treatment is given so that when the student shall have acquired some working vocabulary, he may be able to return here for guidance. Yet it is advisable to read and re-read these pages until the general principles are grasped. Once grasped, they are easily memorised. This does not apply to the auxiliary verbs **AVERE** and **ESSERE,** which must be mastered NOW!

The student may now begin to learn verbs from the alphabetical list given in Lesson 10.

TABLE OF INFLEXIONS OF REGULAR VERBS

Verbs in -ARE				Verbs in -ERE				Verbs in -IRE			
	Present	Imperative	Pres. Subj.		Present	Imperative	Pres. Subj.		Present	Imperative	Pres. Subj.
Port-	**-o**		**-i**	cred-	**-o**		**-a**	dorm-	**-o**		**-a**
	-i	**-a**	**-i**		**-i**	**-i**	**-a**		**-i**	**-i**	**-a**
	-a	**-i**	**-i**		**-e**	**-a**	**-a**		**-e**	**-a**	**-a**
	-iAmo	**-iAmo**	**-iAmo**		**-Amo**	**-iAmo**	**-iAmo**		**-iAmo**	**-iAmo**	**-iAmo**
	-Ate	**-Ate**	**-iAte**		**-Ete**	**-Ete**	**-iate**		**-ite**	**-íte**	**-iAte**
	-ano	**-ino**	**-ino**		**-ono**	**-ano**	**-ano**		**-ono**	**-ano**	**-ano**
	Imperfect	Future	Conditional		Imperfect	Future	Conditional		Imperfect	Future	Conditional
Port-	**-Avo, Ava**	**-erò**	**-erEi**	cred-	**-evo-Eva**	**-erò**	**-erEi**	dorm-	**-Ivo, Iva**	**-irò**	**-irEi**
	-Avi	**-erAi**	**-erEsti**		**-Evi**	**-erAi**	**-erEsti**		**-Ivi**	**-irAi**	**-irEsti**
	-Ava	**-erÀ**	**-erEbbe**		**-Eva**	**-erà**	**-erEbbe**		**-Iva**	**-irà**	**-irEbbe**
	-avAmo	**-erEmo**	**-erEmmo**		**-evAmo**	**-erEmo**	**-erEmmo**		**-ivAmo**	**-irEmo**	**-irEmmo**
	-avAte	**-erEte**	**-erEste**		**-evAte**	**-erEte**	**-erEste**		**-ivAte**	**-irEte**	**-irEste**
	-Avano	**-erAnno**	**-erEbbero**		**-Evano**	**-erAnno**	**-erEbbero**		**-Ivano**	**-irAnno**	**-irEbbero**
	Past Def.		Perf. Subj.		Past Def.		Perf. Subj.		Past Def.		Perf. Subj.
Port-	**-Ai**		**-Assi**	cred-	**-Ei**		**-Essi**	dorm-	**-ii**		**-íssi**
	-Asti		**-Assi**		**-Esti**		**-Essi**		**-ísti**		**-íssi**
	-ò		**-Asse**		**-è**		**-Esse**		**-í**		**-ísse**
	-Ammo		**-Assimo**		**-emmo**		**-Essimo**		**-ímmo**		**-íssimo**
	-Aste		**-Aste**		**-Este**		**-Este**		**-íste**		**-íste**
	-Arono		**-Assero**		**-Erono**		**-Essero**		**-írono**		**-íssero**

GERUNDS: **PortANDO, CredENDO, DormENDO.**
PAST PARTICIPLES: **PortATO, CredUTO, DormITO.**

NOTE. In the above table, the stress is marked by a capital letter or an acute accent only to indicate the stressed syllable—it is never written; the grave accent is always written. Note well the participle endings.

Verbs and nouns—with these, almost anything can be done. Therefore whatever other words are learned as the student proceeds, he should try hard to learn eight or ten each of verbs and nouns daily.

Essere in its compound tenses is conjugated with itself, and not with "to have" as in English. Thus, *I have been* is **Io sono stato** ; *I had been*, **Io ero stato,** and so on.

RULE.—Use *Essere* to form the compound tenses of all intransitive verbs and Avere for transitive. Thus :

Esso è morto, *He has died*
Io ho amato, *I have loved*

(A verb is said to be *transitive* when its action is directed towards some person or thing, and does not stop within itself: *I hit John,* "hit" is a transitive verb. But when the action or feeling is not directed towards something else, and stops within itself, the verb is said to be *intransitive.* Thus *Rivers flow* ; *Mary sleeps* ; *Men die.* "Flow," "sleep," "die," are intransitive verbs.)

Models for Essential Tenses

(1) Regular Verbs.

Infin. PORTARE, *to carry* ; CREDERE, *to believe* ; DORMIRE, *to sleep.*

Pres. Part. PORTANDO, CREDENDO, DORMENDO.

Past Part. PORTATO, CREDUTO, DORMITO.

Present **porto, porti, porta, portiamo, portate, pórtano.**
credo, credi, crede, crediamo, credete, crédono.
dormo, dormi, dorme, dormiamo, dormite, dórmono.

Imperfect **portavo, credevo, dormivo,** etc.

Past Def. **portai, credei, dormii,** etc.

Future **porterò, crederò, dormirò.**

(2) Irregular Verbs

In the lists of irregular verbs in pages 1832 and 1833 the **infinitive**, the **present**, the **past definite**, and the **past participle**, being the essential parts from which all others may be formed, are given. Also other essential parts which may be irregular—the future or present subjunctive, for example, as from the latter the imperative is formed. It may be assumed that **otherwise the verb is regular** or that any other irregularities may be ignored as not of frequent occurrence.

Orthographic Changes for Euphony
(for reference)

When the infinitive ending **-ARE** is preceded :

by **c** or **g**, these letters retain the hard sound *all through the verb* : **oi tronco,** *I cut off,* **noi troncheremo,** *we shall cut off,* **voi tronchiate,** *that you may cut off*; **io pago,** *I pay,* **noi pagheremo,** *we shall pay,* **voi paghiate,** *that you pay.*

by **i**, this vowel is retained when it comes before another, but it is dropped before *all* terminations beginning with **i** : **io conio,** *I coin,* **noi coniamo,** *we coin,* **essi cónino,** *that they coin.*

When the stress is on the **-i**, this vowel must be retained all through the verb : **io spìo,** *I spy,* **tu spìi,** *thou spiest,* **essi spìino,** *that they spy.*

When the infinitive ending is preceded by **ci-**, **gi-**, the vowel **i** is retained through all tenses, except when the termination begins with **i** or **e**. Example **io rintraccio,** *I investigate,* **essi rintráccino,** *that they investigate,* **voi rintraccerete,** *you will investigate*; **io passeggio,** *I walk,* **essi passéggino,** *that they walk,* **voi passeggerete,** *you will walk.*

Infinitives which end in **-gnare** omit **i** from the ending **i-amo.** **Bisognare,** *to require* , **bisognamo,** *we require*

When the termination **-ERE** (unaccented) is preceded by **c** or **g**, both these consonants preserve the soft sound before the vowels **e** and **i** ; but they take the hard sound before the vowels **a** and **o**.

Thus from the verb **torcere,** *to twist,* **egli torc-e,** *he twists* ; but **io torc-o,** *I twist,* **che essi tórc-ano,** *that they twist* ; from **pungere,** *to prick* : **egli pung-e,** *he pricks* ; but **io pung-o,** *I prick,* **che essi púng-ano,** *that they prick.*

Note on Verbs ending -IRE. Although **DORMIRE,** *to sleep,* represents a regular verb ending **-IRE,** a comparatively small number of verbs follow the rules for regular conjugation as given in the Table of Inflexions (page 1823) and the Models (this page) for **DORMIRE.** But the small group which follows **DORMIRE** is important, and is therefore given here for convenience. *Those verbs in large type are essential and must be memorised now.*

THE AUXILIARY VERBS

AVERE, *to have.* Present Participle, **avendo.** Past Participle, **avuto.**

Pres. Indic.	Imperfect	Past Def.	Future	Conditional	Imperative	Pres subj.	Imperfect subj.
ho	**avevo**	**ebbi**	**avrò**	**avrei**		**che io abbia**	**se io avessi**
hai	**avevi**	**avesti**	**avrai**	**avresti**	**abbi**	**che tu abbia**	**se tu avessi**
ha	**aveva**	**ebbe**	**avrà**	**avrebbe**	**abbia**	**che egli abbia**	**se egli avessi**
abbiamo	**avevamo**	**avemmo**	**avremo**	**avremmo**	**abbia-mo**	**che noi abbiamo**	**se noi avessimo**
avete	**avevate**	**aveste**	**avrete**	**avreste**	**abbiate**	**che voi abbiate**	**se voi aveste**
hanno	**avEvano**	**ébbero**	**avranno**	**avrEbbero**	**abbiano**	**che essi, esse ábbiano**	**se essi avEssero**

ESSERE, to be. Present Participle, **essendo.** Past Participle, **stato.**

Pres. Indic.	Imperfect	Past Def.	Future	Conditional	Imperative	Pres subj.	Imperfect subj.
sono	**ero**	**fui**	**sarò**	**sarei**		**che io sia**	**se io fossi**
sei	**eri**	**fosti**	**sarai**	**saresti**	**sii**	**che tu sia**	**se tu fossi**
è	**era**	**fu**	**sarà**	**sarebbe**	**sia**	**che egli sia**	**se egli fosse**
siamo	**eravamo**	**fummo**	**saremo**	**saremmo**	**siamo**	**che noi siamo**	**se noi fossimo**
siete	**eravate**	**foste**	**sarete**	**sareste**	**siate**	**che voi siate**	**se voi foste**
sono	**érano**	**fúrono**	**saranno**	**sarEb-bero**	**siano**	**che essi siano**	**see essi fOssero**

The full list is :

AVVERTIRE, *to warn*	**PENTIRSI**, *to repent*
BOLLIRE, *to boil*	**pervertire**, *to pervert*
CONVERTIRE, *to convert*	**SEGUIRE**, *to follow*
cucire, *to sew*	**SENTIRE**, *to feel*
divertire, *to amuse*	**tossire**, *to cough*
DORMIRE, *to sleep*	**travestire**, *to disguise*
fuggire, *to flee*	**VESTIRE**, *to dress*
PARTIRE, *to depart*	

Frequentative Verbs in -IRE. By far the greatest number of verbs ending in **-IRE** take **-isc-** *between the stem and the endings* given in the Table of Inflexions in page 1823, but only in some persons of the Present, the Present Subjunctive, and consequently the Imperative. Take, for example, the essential verb **FINIRE**, *to finish* :

FINIRE, *to finish* ; **FINENDO**, *finishing* ; **FINITO**, *finished.*

Present	**FINISCO, FINISCI, FINISCE, finiamo, finite, FINÍSCONO.**
Imperf.	**finivo**, etc
Past Def.	**finii**, etc.
Future	**finirò**, etc
Pres Subj	**Che io FINISCA, tu FINISCA, egli FINISCA, noi finimao, voi finiate, essi FINÍSCANO.**
Imperative	**FINISCA** (Polite form) *Finish !* Plural · **FINÍSCANO.**

These **-isc-** verbs are called " **Frequentative** " in Italian.

RULE. *All -IRE verbs which are neither irregular nor conjugated like Dormire* (see list above) *are conjugated like Finire.*

List of Verbs Conjugated like Finire. The following list is given for convenience. These **DORMIRE** and **FINIRE** verbs together with the few irregular **-IRE** verbs given later (pages 1831, 1832) represent the most frequently recurring verbs of this conjugation.

Verbs with the Inflexion -ISC-

AGIRE, *act*	**GUARIRE**, *cure*
CAPIRE, *understand*	**impallidire**, *grow pale*
CONTRIBUIRE, *contribute*	**IMPAURIRE**, *frighten*
COSTRUIRE, *construct*	**IMPEDIRE**, *hinder*
DEFINIRE, *define*	**INDEBOLIRE**, *weaken*
demolire, *demolish*	**INFASTIDIRE**, *annoy*
DIFFERIRE, *differ*	**ISTRUIRE**, *instruct*
digerire, *digest*	**OBBEDIRE**, *obey*
DIMINUIRE, *diminish*	**PERSEGUIRE**, *pursue*
DISOBBEDIRE, *disobey*	**PREFERIRE**, *prefer*
DISUNIRE, *separate*	**PROIBIRE**, *prohibit*
FALLIRE, *fail*	**PULIRE**, *clean*
favorire, *favour*	**PUNIRE**, *punish*
ferire, *wound*	**RESTITUIRE**, *restore*
fiorire, *blossom, flourish*	**SMARRIRE**, *lose, mislead*
FORNIRE, *furnish*	**SMENTIRE**, *contradict*
fruíre, *enjoy the fruits of*	**SOSTITUIRE**, *substitute*
GARANTIRE, *guarantee*	**SPARIRE**, *disappear*
	SPEDIRE, *dispatch*
	STABILIRE, *establish*
STUPIRE, *to be amazed*	**SVANIRE**, *vanish*
SUPPLIRE, *supply*	**UNIRE**, *unite*

Verbs in -IRE like Dormire or Finire. There are some verbs which may be conjugated like either **Dormire** or **Finire** :

APPLAUDIRE, *to applaud* ·	**applaudo or applaudisco**
AVVERTIRE, *to warn* ·	**avverto or avvertisco** (rare)
BOLLIRE, *to boil :*	**bollo or bollisco** (rare)
COMPARTIRE, *divide* ·	**comparto or compartisco**
INVERTIRE, *invert :*	**inverto or invertisco**
MENTIRE, *to tell lies* ·	**mento or mentisco**
NUTRIRE, *to nourish .*	**nutro or nutrisco**
SCORCIRE, *shorten :*	**scorcio or scorcisco**

NOTE. **Apprire**, *to appear* : **APPAIO or APPARISCO**, *I appear* ; **PARTIRE**, *to depart, leave* : **io parto**, *I set off* ; but **io partisco** means *I divide* ; **DIVERTIRE** means both to *amuse* and *to divert (turn aside)* : **io diverto**, *I amuse* ; **io divertisco**, *I divert.*

The Passive of Verbs

The Passive is formed in Italian as in English by using the verb *to be* (*essere*) in the mood, tense, and person required, with the Past Participle of the verb of which the Passive is required. Thus :

I am praised, **Sono lodato** (from **LODARE**, *to praise*)

The Past Participle in Italian agrees in gender and number with the subject to which it refers. Thus :

È lodato means *He is praised.*
È lodata means *She is praised.*
Sono lodati means *They* (i e. men) *are praised.*
Sono lodate means *They* (women) *are praised.*
Siamo lodati means *We are praised* (men), etc.

CHIAMARE, *to call* ; **ESSERE CHIAMATO**, *to be called.*

Present	**io sono chiamato**, *I am called.*
Imperfect	**io ero or era chiamato**, *I was called.*
Past Def.	**io fui chiamato**, *I was called.*
Future	**io sarò chiamato**, *I shall be called.*
Condit.	**io sarei chiamato**, *I should be called.*
Imperative	**sii (tu) chiamato**, *be called.*

The student should now understand :

io sono stato chiamato, *I have been called.*
io ero or era stato chiamato, *I have been called.*
io fui stato chiamato, *I had been called.*
io sarò stato chiamato, *I shall have been called.*
io sarei stato chiamato, *I should have been called.*
(che) io sia chiamato, *(that) I be called.*
(che) io fossi chiamato, *(that) I were called.*
(che) io sia stato chiamato, *(that) I have been called.*
(che) io fossi stato chiamato, *(that) I had been called.*
éssere stato, -a, -i, -e, chiamato, -a, -i, -e, *to have been called.*
essendo stato, -a, -i, -e, chiamato, -a, -i, -e, *having been called.*
stato, -a, -i, -e, chiamato, -a, -i, -e (*having*) *been called.*

VENIRE, *to come*, is often used instead of **ESSERE** in the simple tenses of the passive, but in the compound **ESSERE** must always be used : **Vengo (or sono) punito,** *I am punished* ;

Vengo (or **sono**) **chiamato,** *I am called.* But **Sono stato punito,** *I have been punished.*

The passive is also (and very frequently) expressed by the Reflexive (for which see below):

Come si pronunzia questa parola ? or **Come é pronunziata questa parola ?**	*How is this word pronounced ?*

Si parla italiano, *Italian* (is) *spoken.*
si dice, *it is said, people say* (French *On dit*).

The compound tenses of this Reflexive Passive are formed with *E*SSERE :

Si é parlato italiano, *Italian was* (has been) *spoken.*

Si é detto che avremo la guerra, *It has been said that we shall have war.*

vietare, *to prohibit* : **É vietato fumare.**
É stato vietato fumare.

By after a Passive must be rendered by **da** : **Io sono amato da mia madre,** *I am loved by my mother.*

Reflexive Verbs

A verb is called Reflexive when (*a*) the action is performed and suffered by the subject and (*b*) when two personal pronouns instead of one are used in conjugation in order to express the action. In English comparatively few verbs are reflexive, but the reflexive form is common in Italian ; though the Italian need not necessarily be translated by the English reflexive. Thus: **vestirsi,** *to dress oneself,* is a reflexive verb in both languages, but **pentirsi** means to *repent,* and is by its nature reflexive in Italian : **Io mi pento,** *I repent.* There is no difference in the conjugation of the Italian verbs which are naturally reflexive and those which are obviously reflexive in both languages.

LAVARSI, *to wash oneself.*
io mi lavo, *I wash myself.*
tu ti lavi, *thou washest thysel,.*
egli si lava, *he washes himself.*
noi ci laviamo, *we wash ourselves.*
voi vi lavate, *you wash yourselves.*
essi si lávano, *they wash themselves.*
io mi lavavo, *I washed myself,* or *was washing myself.*
io mi lavai, *I washed myself.*
io mi laverò, *I shall wash myself.*
io mi laverei, *I should wash myself.*
lAvati, *wash thyself.*
si lavi, *let him wash himself.* **Si lavi,** *wash yourself* (polite).
laviAmoci, *let us wash ourselves.*
lavAtevi, *wash yourselves.*
si lAvino, *let them wash themselves* (*yourselves*).
io mi sono lavato, *I have washed myself,* etc.
io mi ero or **era lavato,** *I had washed myself.*
io mi fui lavato, *I had washed myself.*
io mi sarò lavato, *I shall have washed myself.*
io mi sarei lavato, *I should have washed myself.*
(che) io mi lavi, (that) *I wash myself,* etc.
lavándosi, *washing oneself.*
(che) io mi sia lavato, (that) *I have washed myself.*
(che) io mi fossi lavato, (that) *I had washed myself.*
ésseri lavato, -a, -i, -e, *to have washed oneself.*
essendosi lavato, -a, -e, -i, *having washed oneself.*

Similarly:

Mi pento, ti penti, si pente, ci pentiamo, vi pentite, si pEntono, *I repent,* etc.

NOTE. The auxiliary ***E*ssere** is used to form the compound tenses of Reflexive verbs : **Io mi sono lavato : io mi sono pentito**—*I have washed myself, I have repented.*

Useful Italian Reflexive Verbs

to go away, **ANDARSENE**
to fall asleep, **ADDORMENTARSI**
to fancy, **IMMAGINARSI (di)**
to remember, **RICORDARSI (di)**
to resign, **DIMETTERSI (da)**
to shave, **RADERSI**
to take leave, **CONGEDARSI (da)**
to trust, **FIDARSI (di)**
to wonder (at), **SORPRENDERSI MARAVIGLIARSI (di)**
to forget, **DIMENTICARSI**
to fall sick, **AMMALARSI**
to rest, **RIPOSARSI**
to be ashamed, **VERGOGNARSI**
to get married, **MARITARSI**
to be well, unwell, **SENTIRSI BENE, MALE**

Note that most of these end in -ARE.

Examples of Reflexives

What is your name ? **Come si chiama lei ?**

He has dropped his handkerchief, **Gli è caduto il fazzoletto.**

What has she done to herself ? **Che cosa si è fatto ?**

She has cut her finger, **S'è tagliato un dito.**

While shaving himself, he has cut his chin, **Nel farsi la barba, s'è tagliato il mento.**

I do not wonder at it, **Non mi sorprende.**

What do you think of it ? **Che ve ne pare ?**

Wash your face and hands before you put on your hat, **Lavati il viso e le mani, prima di metterti il cappello** (familiar form).

He did not take off his coat, **Non si levò la giacca.**

He is very conceited, **Se la pretende molto.**

The Negative of Verbs

To form the negative of any verb or part of a verb, the word **non,** *not,* is placed before the verb, and before the auxiliary in compound tenses : **Io non ho,** *I have not* ; **Io non ho avuto,** *I have not had* ; **Io non parlo,** *I do not speak* ; **Non ho parlato,** *I have not spoken.*

When an objective pronoun is used, then the **non** comes before it : **Egli non mi responde,** *He does not reply to me.* Phrases with the negative words *nothing,* **niente, nulla** ; *nobody,* **nessuno** ; *never,* **mai**—require in Italian the additional negative **non.** *I have nothing,* **Non ho niente** ; *I see nobody,* **Non veggo nessuno** ; *I never finish,* **Non finisco mai.** English phrases with the negation *no* before a noun are rendered by **non** : *I have no money,* **Non ho denaro.**

NOT AT ALL, NON . . . PUNTO. *I have no friends at all,* **Io non ho punto amici.**

NO MORE, NO LONGER, NON . . . PIÙ. *She has no longer* (more) *patience,* **Essa non ha più pazienza.**

NOT TO before an infinitive, **DI NON.** *I told you not to do it*, **Vi dissi di non farlo.** *Not to have anything*, **Di non aver niente.** NOTE. *Why not?* **Perchè no?** *I say not*, **Dico di no.** *I believe not*, **Credo di no.**

Negative Imperative is expressed by **NON** placed before the positive imperative. Thus:

Non interrompere chi parla, *Do not interrupt the person who is speaking.* **Non dormire qui,** *Do not sleep here* (familiar). **Non parli,** *Do not speak* (polite).

To Use the Verb Interrogatively

To ask a question, place the subject pronoun after the verb. Thus: *Have I?* **Ho io?** The English "Do you?" is also expressed by placing the pronoun after the verb. Thus: *Do you speak Italian?* **Parla lei italiano? Non io**—*Not I!* (Or **io no**).

Negative Interrogative of Verbs. Place **non** first, then the verb, then the pronoun. Thus: *Do you not speak Italian?* **Non parla lei italiano?** *Do you not understand?* **Non capisce lei?**

In Italian it is very usual to ask a question merely by modulating the voice, without changing the construction of a direct statement —a useful formula for the beginner:

Lei parla inglese? (Do) *you speak English?* **Lei capisce bene ciò che io dico?** (Do) *you understand well what I am saying?* **Suo padre verrà?** *Your father will come?* The formula can be made more convincing by adding: **Non è vero?** *Is it not so* (true)? **Lei vuole un gelato, non è vero?** *You would like to have an ice, would you not?*

Impersonal Verbs

These are so called because as a rule they do not refer to a person, and they are used only in the third person singular:

It thunders, **TUONA.**
It rains, **PIOVE.**
It is bad weather, **FA CATTIVO TEMPO.**
It freezes, **GELA.**
It snows, **NEVICA.**
The wind blows, **TIRA VENTO.**
It is cold, **FA FREDDO.**
It is warm, **FA CALDO.**
It is fine, **FA BEL TEMPO.**
It appears, **PARE.**
It happens, **ACCADE.**
I happened to, **MI ACCADE DI.**
It is proper to . . . **CONVIENE . . .**
It is necessary to, **BISOGNA.**
It matters not, **NON IMPORTA.**
It is enough, **BASTA.**
It pleases, **PIACE.**
It begins, **COMINCIA.**
It has happened (that), **È AVVENUTO (che).**

To Translate "There is," "There are"

The English Impersonal Verb "*there to be*" is expressed in the same way in Italian; **ésserci** or **ésservi**, the adverb *THERE* being **ci** or **vi**:

There is, **c'è** or **v'è.**
There are, **ci sono** or **vi sono.**
There was, **c'era** or **v'era**, or **ci fu** or **vi fu.**
There were, **c'érano** or **ci fúrono.**
There will be, **ci sarà** or **ci saranno.**
There would be, **ci sarebbe** or **ci sarEbberro.**
There has been, **c'è stato-a.**
There have been, **ci sono stati-e.**
That there may be, **che ci sía** or **síano.**
That there must be, **bisogna che ci sía** or **che ci síano.**
Is there? **v'è** or **c'è?** *was there?* **v'era** or **c'era?**

To form the negative simply place **NON** before any of the above. **non c'è**, *there is not*; **non c'era**, *there was not*, etc.

Examples:

C'è il sole oggi, *There is sun today.*

C'era la moglie di mio fratello, *There was* (present) *my brother's wife.*

Thither (to there), is translated by **CI** or **VI.**

Thence (from there), is translated by **NE.**

Va lei a casa? *Are you going home* (to your house)?

No, ne vengo, *No, I am coming from there.*

È stato lei in Italia? *Have you been in Italy?*

No, ma vi andrò quest'anno, *No, but I shall go there this year.*

(Students acquainted with French may compare Italian **NE** with French *en*; and Italian **VI** and **CI** with French *y*. And Italian **c'è, v'è** with French *il y a*):

Hai pensato a questa cosa? *Have you thought of this?*

Ci ho pensato, *I have thought of it* (French: *J'y ai pensé*).

LESSON 7

Irregular Verbs in -are, -ire, and -re

Do not start this lesson until you have a very good idea of the Regular Verbs and Auxiliaries. And you must take this lesson gently. There is no need to master it thoroughly just yet, but you should read it right through two or three times to get an idea of the general principles, and then concentrate on the parts of the lesson which come before the General List of Essential Irregular Verbs before the Exercise. The list of Italian irregular verbs may appear long, but the student will find that many irregularities follow definite rules and present little difficulty. Irregularities generally occur in the

Present Indicative.
Present Subjunctive.
Imperative.
Past Definite.
Past Participle.
Future and Conditional (in a few verbs only).

Rules for Irregular Verbs

(1) *Past Definite* irregularities occur in the 1st person singular, which ends in **i.** Also in

the third person singular, which ends in **e** ; and in the third person plural, which adds **-ro** to the third person singular. Exceptions: **dare, stare, fare, porre, dire**—which see.

(2) The *Imperative* follows the same irregularities as the Present Subjunctive for the polite forms (and as the Present Indicative for 2nd persons).

(3) The *Future* and *Conditional* usually have the same sort of irregularity, which is often merely a slight contraction or alteration, rather than a real irregularity. Thus **andrò** instead of **anderò**.

(4) **All derivative and compound verbs follow their simple verbs in irregularities.** Thus: **DISFARE,** *to undo, unmake,* is conjugated exactly like **FARE,** *to do, to make.*

All exceptions to this rule will be noted. The student must use his intelligence to judge when a verb is a derivative or compound and when it is not.

For example, **SOTTOSTARE** is clearly a compound of **sotto,** *underneath, below,* and stare, *to stand,* because it means *to be beneath, to stand beneath* : so it follows **stare.** But **COSTARE,** *to cost,* is (obviously) not related to **stare.** It is regular.

(5) The *Imperfect Indicative* is always regular, except in **dare, fare, porre** (which see).

(6) The *Imperfect Subjunctive* is always regular, except in **dare, stare, trarre,** which take **-essi** instead of **-assi** : and **dire, fare, porre,** which make **dicessi, facessi, ponessi.**

(7) Tenses which are not given in the lists that follow may be assumed to be regular.

In learning the irregular verbs the student should memorise the principal parts: *infinitive, present indicative, past definite, future,* and *past participle. These essential parts must be known, as from them all others can be made.*

Thus the way to memorise **potere,** *to be able,* is: **potere, posso, potei, potrò, potuto.**

Irregular Verbs ending in -ARE. There are only four irregular verbs in this conjugation: **ANDARE,** *to go* ; **DARE,** *to give* ; **FARE,** *to make, do* ; **STARE,** *to stand, be, stay.* These four verbs must be known thoroughly.

ANDARE, *to go*

Pres. Ind.	**vado, vai, va, andiamo, andate, vanno**
Future	**andrò, andrai, andrà, andremo, andrete, andranno**
Condit.	**andrei, andresti, andrebbe, andremmo, andreste, andrEbbero**
Imper.	**va', vada, andiamo, andate, vAdano**
Pres. Sub.	**ch'io vada, che tu vada, ch'egli vada, che andiamo, che andiate, che vAdano**

Regular are: the Imperfect, **andavo,** etc.; the Past Definite, **andai,** etc.: the Imperfect Subjunctive, **ch'io andassi,** etc.: the Present Participle, **andante**; the Gerund, **andando,**[1] and the Past Participle, **andato.** The Future and Conditional are sometimes also conjugated regularly; as **anderò, anderai; anderei, anderesti,** etc.

[1] The Gerund should be avoided by the beginner— it is given here merely for reference.

DARE, *to give*

Pres. Ind.	**dò, dai, dà, diamo, date, danno**
Past Def.	**diedi, desti, diede (dette or diè), demmo, deste, diEdero (dEttero or diErono)**
Future	**darò, darai, darà, daremo, darete, darAnno**
Condit.	**darei, daresti, darebbe, daremmo, dareste, darEbbero**
Imp.	**dà, dia, diamo, date, diano (or dieno).**
Pres. Subj.	**ch'io dia, che tu dia, ch'egli dia, che diamo, che diate, che diano**
Imp. Sub.	**ch'io dessi, che tu dessi, ch'egli desse, che dEssimo, che deste, che dEssero**

Regular: *Imperfect,* **dava,** etc. *Present Participle*: **dante**; *Gerund*: **dando**; *Past Participle*: **dato.**

Ridare, *to give again,* is conjugated in the same way, but takes an accent in the Present Indicative: **ridò, ridai, ridà,** etc. Derivatives of **dare** of more than three syllables, as **circondare,** *to surround,* etc., are conjugated regularly.

FARE, *to make, to do*

Pres. Ind.	**fo (faccio), fai, fa, facciamo, fate, fanno**
Past Def.	**feci, facesti, fece, facemmo, faceste, fEcero**
Pres. Sub	**faccia**
Future	**farò,** etc.
Imp.	**fa**
Participles	**facente** (Pre.), **FATTO** (past). And one of the few useful Gerunds: **FACENDO,** *doing.* **Facendo così**—*doing so,* or *while doing so.*

STARE, *to stand, to be, stay*

Pres. Ind.	**sto, stai, sta, stiamo, state, stanno**
Past Def.	**stetti, stesti, stette, stemmo, steste, stEttero**
Future	**starò, starai, starà, stemo, starete, staranno**
Pres. Sub.	**stai, stia, stia, stiámo, stiáte, stíano**
Imp	**sta,** etc.
Participles	**stante, STATO**

Idioms for Irregular Verbs in -ARE. As already indicated, the four verbs **andare, dare, fare** and **stare,** are of frequent occurrence and should be known. Another good reason for mastering them completely is that they can be used to form phrases or idioms that are useful. Some of these are given below, but they need not be mastered on a first perusal of this Course —let it suffice for the present to know the four verbs well. *On second perusal* learn the following idioms:

ANDARE, *to go*

andare a cavallo, *to ride*
andare a piedi, *to go on foot, to walk*
andare a male, *to decay, to decline in health*
andare di bene in meglio, *to get better and better*
andare di male in peggio, *to get worse and worse*
andare in cóllera, *to get angry*
andare superbo, *to be proud*

FARE, *to do, make*

fare attenzione, *to pay attention, be careful*
far bel tempo, cattivo tempo, *to be fine, to be bad weather*
far caldo, freddo, *to be warm, cold* (of the weather)
far colazione, *to breakfast*
far fare, *to have done*
far male, *to hurt*

fare un bagno, una passeggiata, *to take a bath, a walk*
fare una visita, *to pay a call, a visit*
far naufragio, *to be shipwrecked*
far vista (di), *to pretend*

DARE, *to give*
dar ad intendere, *to make believe*
dar fuoco, *to set on fire*
dar in préstito, *to lend*
dar luogo, *to occasion, to give rise to*
dar parola, *to give one's word*

STARE
To be well, ill or *badly*, either in health, condition, or personal appearance, is rendered by the verb **stare** in Italian instead of **Essere**. **Non sta bene,** *He is unwell;* **Sta scOmoda,** *She is uncomfortable.*

star di casa, *to live to inhabit*
lasciare stare, *to let a person or a thing alone*
stare allegro or **di buon ánimo,** *to cheer up*
stare quieto, *to be quiet*
stare in forse, *to be doubtful*
stare in piede, *to stand* (be on foot)
stare zitto, *to be silent*

Other Irregulars in -ARE. Verbs which take either the diphthong **uo** when stress is laid on it, or simply the vowel **o** if the tonic accent is on another syllable, may also be considered as irregular verbs, as :

giocare, *to play*	**sonare,** *to sound, to ring*
rinnovare, *to renew*	**tonare,** *to thunder*
risonare, *to resound*	**votare,** *to empty*
rotare, *to wheel*	

This is a model for these irregular forms :
Pres. Ind · **vuoto, vuoti, vuota, vuOtano**
Imperat. · **vuota, vuoti, vuOtino**
Pres Subj **vuoti, vuoti, vuoti, vuOtino**

Irregular Verbs in -ERE. This is the most numerous series of irregular verbs. For convenience, the **-ERE** verbs may be classified under three heads:

(1) **-*E*RE** in which the **E** is stressed.

(2) **-ĔRE** in which the **E** is unstressed

(3) Very irregular **-RE** verbs.

As the second group is the most numerous, and the first of most frequent occurrence, it is worth while to memorise a list of those verbs which have a stressed *-E-* :

AV*E*RE, *to have*	**POT*E*RE,** *to be able, to be capable of*
CAD*E*RE, *to fall*	**RIMAN*E*RE,** *to remain*
DISSUAD*E*RE, *to dissuade*	**SAP*E*RE,** *to know*[1]
DOL*E*RE, *to pain, ache, grieve*	**SED*E*RE,** *to sit*
DOV*E*RE, *to be obliged, to owe*	**SOL*E*RE,** *to be wont, accustomed*
GIAC*E*RE, *to lie (down), rest*	**TAC*E*RE,** *to be silent*
	TEM*E*RE, *to fear*
GOD*E*RE, *to enjoy*	**TEN*E*RE,** *to keep to hold*
PAR*E*RE, *to seem, appear*	**VAL*E*RE,** *to be worth*
PERSUAD*E*RE, to *persuade*	**VED*E*RE,** *to see*
PIAC*E*RE, *to please*	**VOL*E*RE,** *to wish, be willing, want*

Of these **god*e*re** and **tem*e*re** are conjugated like **credere,** the others as follows :

(1) Irregular Verbs ending -*E*RE (stressed).

CAD*E*RE, *to fall.*

Past Def. **caddi, cadesti, cadde, cademmo cadeste, cAddero**
Future **cadrò, cadrai, cadrà, cadremo, cadrete, cadranno**
Condit **cadrei, cadresti, cadrebbe, cadremmo, cadreste, cadrEbbero**

Regular : Present Indicative : **cado,** etc *Imperfect :* **cadeva,** etc. *Imperative* · **cadi,** etc. *Present Subjunctive* · **ch'io cada,** etc. *Past Participle* · **caduto.**

The Future and Conditional are regular

DISSUAD*E*RE, *to dissuade*
Past Def. **dissuasi, dissuadesti, dissuase, dissuademmo, dissuadeste, dissuAsero**
Past Part. **dissuaso**

Persuad*E*re, *to persuade,* is conjugated like **dissuad*E*re.**

DOL*E*RE—more often reflexive—**dolersi,** *to pain, ache, grieve*
Pres. Ind **mi dolgo, ti duoli, si duole, ci doliamo (or dolghiamo), vi dolete, si dOlgono**
Past Def **mi dolsi, ti dolesti, si dolse, ci dolemmo, vi doleste, si dOlsero**
Future : **mi dorrò, ti dorrai, si dorrà, ci dorremo, vi dorrete, si dorranno**
Past Part **doluto**

DOV*E*RE, *to owe, to be obliged, compelled*
Pres. Ind **devo (or debbo), devi, deve (debbe or dee), dobbiamo, dovete, dEvono (or dEbbono)**
Past Def **dovei (or dovetti), dovesti, dovè (or dovette), dovemmo, doveste, dovErono (or dovEttero)**
Future **dovrò, dovrai, dovrà, dovremo, dovrete, dovranno**
Pres Sub **ch'io debba, che tu debba, ch'egli debba, che dobbiamo, che dobbiate, che dEbbano**
Past Part. **dovuto**

GIAC*E*RE, *to lie down, rest*
Pres Ind. **giaccio, giaci, giace, giacciamo, giacete, giAcciono**
Past Def. **giacqui, giacesti, giacque, giacemmo, giacesti, giAcquero**
Imperative **giAccia, giAcciano**
Pres. Subj **ch'io giAccia**
Past Part. **giaciuto**

N.B. **Piac*E*re,** *to please,* and its derivatives are conjugated like **giac*E*re**

PAR*E*RE, *to appear, seem*
Pres Ind. **paio, pari, pare, paiamo parete, pAiono**
Past Def **parvi (or parsi), paresti, parve (or parse), paremmo, pareste, pArvero (or pArsero)**
Past Part. **parso (or paruto)**

Rarely used except in the forms . **mi pare,** *it seems to me* , **mi parve,** *it seemed to me* Use **SEMBRARE** (reg.) *to seem,* instead.

POT*E*RE, *to be able* (purely physical ability).
Pres. Ind. **posso, puoi, può, possiamo, potete, pOssono**
Past Def. **potei (or potrai), potesti, potè (or potette), potemmo, poteste, potErono (or potEttero)**
Future : **potrò, potrai, potrà, potremo, potrete, potranno**
Pres. Subj. **ch'io possa, che tu possa, ch'egli possa, che possiamo, che possiate, che pOssano**
Pres. Part **potente :** *Gerund* **: potendo**
Past Part. **potuto.** No *Imperative.*

[1] **Sapere,** *to know* (demands intellectual ability) ; **conoscere,** *to know* (in a superficial sense).

RIMANERE, *to remain*

Pres. Ind. **rimango, rimani, rimane, rimaniamo, rimanete, rimAngono**
Past Def. **rimasi, rimanesti, rimase, rimanemmo, rimaneste, rimAsero**
Future **rimarrò, rimarrai, rimarrà, rimarremo, rimarrete, rimarranno**
Condit. **rimarrei,** etc.
Imp. **rimanga, rimAngano** (polite forms only)
Pres. Subj. **ch'io rimanga, che tu rimanga, ch'egli rimanga, che rimaniamo, ch rimaniate, che rimAngano**
Past Part. **rimasto**

SAPERE, *to know*

Pres. Ind. **so, sai, sa, sappiamo, sapete, sanno**
Past Def. **seppi, sapesti, seppe, sapemmo, sapeste, sEppero**
Future **saprò, saprai, saprà, sapremo, saprete, saprAnno**
Condit. **saprei, sapresti, saprebbe, sapremmo, sapreste, saprEbbero**
Imp. **sAppia, sAppiano**
Pres. Subj. **ch'io sAppia, che tu sAppia, ch'egli sAppia, che sappiamo, che sappiate, che sAppiano**
Pres. Part. **sapiente**
Past Part. **saputo**

AntisapEre, *to foresee,* and other derivatives of **sapEre** are conjugated in the same way.

SEDERE, *to sit*

Pres. Ind. **siedo** (or **seggo**), **siedi, siede, sediamo, sedete, siEdono**
Past Def. **sedei** (or **sedetti**), **sedesti, sedè** (or **sedette**), **sedemmo, sedeste, sedErono** (or **sedEttero**)
Future **sederò, sederai, sederà, sederemo, sederete, sederanno**
Condit. **sederei, sederesti, sederebbe, sederemmo, sedereste, sederEbbero**
Imp. **siedi sieda, siEdano (segga, sEggano)**
Pres. Subj. **ch'io sieda, che tu sieda, ch'egli sieda, che sediamo, che sediate, che siEdano**
Past Part. **seduto**

The shortened regular form of Future and Conditional is also much used: **sedrò,** etc.

PossedEre, *to possess* and other derivatives are similarly conjugated.

SedErsi, *to sit down*—also like **sedEre**

SOLERE, *to be wont*

Pres. Ind. **soglio, suoli, suole, sogliamo, solete, sOgliono**
Imperf. **solevo, solevi, soleva, solevamo, solevate, solEvano**
Gerund **solendo**
Past Part. **sOlito**

The past of this verb has rather the nature of an adjective. Thus: **io sono sOlito** corresponds to its equivalent **io soglio; io ero sOlito** or **io solevo,** etc., meaning *I am, was wont.*

TACERE, *to be silent*

Pres. Ind. **taccio, taci, tace, tacciamo, tacete, tAcciono**
Past Def. **tacqui, tacesti, tacque, tacemmo, taceste, tacquero**
Imp.: **taccia, tAcciano**
Past Part. **taciuto**

Avoid confusion with the regular verb **tacciare,** *to accuse.*

TENERE, *to keep, to hold*

Pres. Ind. **tengo, tieni, tiene, teniamo, tenete, tEngono**
Past Def. **tenni (tenei or tenetti), tenesti, tenne, tenemmo, teneste, tEnnero**
Future **terrò, terrai, terrà, terremo, terrete, terranno**
Condit. **terrei, terresti, terrebbe, terremmo, terreste, terrEbbero**
Imp. **tenga, tEngano**
Pres. Subj. **ch'io tenga, che teniamo**
Past Part. **tenuto**

Derivatives of **tenEre** are conjugated in the same way. Compare with **VENIRE,** *to come.*

VALERE, *to be worth*

Pres. Ind. **valgo, vali, vale, valghiamo (or valiamo), valete, vAlgono (or vAgliono)**
Past Def. **valsi, valesti, valse, valemmo, valeste, vAlsero**
Future **varrò, varrai, varrà, varremo, varrete, varranno**
Condit. **varrei,** etc.
Pres. Subj. **ch'io valga**
Past Part. **valuto** or **valso** (both used)

EquivalEre, *to be equivalent;* **prevalere,** *to prevail,* etc., are similarly conjugated.

VEDERE, *to see*

Pres. Ind. **vedo, vedi, vede, vediamo, vedete, vEdono**
Past Def. **vidi, vedesti, vide, vedemmo, vedeste, videro**
Future **vedrò, vedrai, vedrà, vedremo, vedrete, vedranno**
Condit. **vedrei,** etc.
Imp. **veda, vEdano**
Pres. Subj. **ch'io veda**
Past Part. **veduto** or **visto** (both common)

In the Future and Conditional the full regular form is also used: **vederò,** or **vedrò.**

AntivedEre, *to foresee,* and other derivatives are conjugated in the same way.

VOLERE, *to wish, to will, want, be willing to*

Pres. Ind. **voglio (or vo), vuoi, vuole, vogliamo, volete, vOgliono**
Past Def. **volli, volesti, volle, volemmo, voleste, vOllero**
Future **vorrò, vorrai, vorrà, vorremo, vorrette, vorranno**
Condit. **vorrei,** etc.
Pres. Subj. **ch'io voglia**
Past Part. **voluto**
Gerund **volendo**

Derivatives are conjugated similarly: **rivolEre,** *to wish again;* **svolEre,** *to change one's mind.*

(2) Irregular Verbs ending -ĔRE (Unstressed).

This is the most numerous group in the series of **-ERE** irregular verbs—so numerous that it is worth while learning the short list of essential *regular* unstressed **-ERE** verbs:

BATTERE, *to beat*	**PENDERE,** *to hang (from)*
CEDERE, *to yield*	**PERDERE,** *to lose*
CREDERE, *to believe*	**RICEVERE,** *to receive*
MESCERE, *to mix*	**RIPETERE,** *to repeat*

SPLENDERE, *to shine* **VENDERE,** *to sell*
all conjugated like **CREDERE.**

Having memorised that list, assume that all other **-ERE** verbs are irregular. And note that most of the remaining (unstressed) **-ĔRE** verbs are irregular only in the Past Definite and Past Participle. The Past Definite endings are :

-i, -esti, -e, -emmo, -este, -ero

The Past Participle is generally irregular, and must be memorised. All other tenses are generally regular.

(3) **Very Irregular Verbs ending in -RE.** There are only four verbs ending in **-RE** which are very irregular, do not come under any of the above heads, and are useful. **Addurre** must be known, because all verbs ending in **-URRE** are similarly conjugated. **Bere** (or **bevere**) is an essential verb, and so also is **porre. Trarre** must be known, because, like **adurre,** it is the model for many verbs ending **-arre.** So :

ADDURRE, *to adduce*

Pres. Part.	**adducente**
Gerund	**adducendo**
Past Part.	**addotto**
Pres. Indic.	**adduco, adduci, adduce, adduciamo, adducete, addUcono**
Imperf.	**adducevo, adducevi, adduceva, adducevamo, adducevate, adducevano**
Past Def.	**addussi, adducesti, addusse, adducEmmo, adduceste, addUssero**
Future	**addurrò, addurrai, addurrà, addurremo, addurrete, addurranno**
Imp.	**adduca : addUcano**— Polite forms only.

TRARRE, *to draw*

Pres. Indic.	**traggo, trai, trae, traiamo, traete, trAggono**
Imperf.	**traeva, traevi,** etc.
Past Def.	**trassi, traesti, trasse, traemmo, traeste, trAssero**
Future	**trarrò, trarrai,** etc
Imp.	**tragga, trAggano** (polite forms)
Pres. Subj.	**ch'io tragga, che tu tragga, ch'egli tragga, che traiamo, che traiate, che trAggano**
Imp. Subj.	**ch'io traessi, che tu traessi,** etc.
Pres. Part.	**traente**
Gerund	**traendo**
Past Part.	**tratto**

BERE or **BEVERE,** *to drink*[1]

Part.	**bevendo, bevuto**
Pres. Indic.	**bevo (beo), bevi (bei), beve (bee). beviamo, bevete, bEvono (bEono)**
Imperf.	**bevevo (beveo), bevevi, beveva, bevevamo,** etc.
Past Def.	**bevvi (bevetti** or **bevei), bevesti (beesti), bevve (bevette), bevemmo (beemmo), beveste, bEvvero** or **bevEttero**
Future	**berrò** or **beverò, berrai** or **beverai,** etc., **berremo,** etc.
Imp.	**beva, bEvano** (Polite forms)

PORRE, *to put*

Pres. Indic.	**pongo, poni, pone, poniamo, ponete, pOngono**
Imperf.	**ponevo,** etc., **ponevamo,** etc.
Past Def.	**posi, ponesti, pose, ponemmo,** etc.
Future	**porrò,** etc.
Condit.	**porrei,** etc.
Imp. :	**poni, ponga, poniamo, ponete, pOngano**
Pres. Subj.	**che io ponga, poniamo,** etc.
Imp. Subj.	**che io ponessi,** etc., **ponessimo,** etc.

SUPORRE, *to suppose,* is conjugated similarly.

Irregular Verbs in -IRE. The essential irregular verbs in **-IRE** are :

DIRE, *to say, tell*	**UDIRE,** *to hear*
MORIRE, *to die*	**USCIRE,** *to go out, away*
SALIRE, *to ascend, mount*	**VENIRE,** *to come*

and their derivatives, similarly conjugated.

DIRE, *to tell, say*

Pres. Ind.	**dico, dici, dice, diciamo, dite, dicono**
Future	**dirò** (also **dicerò**)
Imperf.	**dicevo,** etc.
Past Def.	**dissi, dicesti, disse, dicemmo, diceste. dissero**
Imper.	**di', dica, diciamo, dite, dícano**
Pres. Sub.	**ch' io dica,** etc.
Gerund	**dicendo**
Past Part	**DETTO**

Similarly : **contraddire,** *to contradict* , **predire,** *to predict,* etc.

MORIRE, *to die*

Pres. Ind.	**muoio, muori, muore, moriamo, morite, muOiono**
Pres. Subj.	**che io muoia, . . muoia, . . muoia, . . moriamo, moriate, muOiano**
Past Part. :	**morto**

SALIRE, *to ascend*

Pres. Ind.	**salgo, sali, sale. saliamo. salite, sàlgono**
Pres. Sub.	**che io salgo,** etc.
Imperative	**sali, salga, salghiamo, salite, sàlgano**
Past Part.	**salito**

UDIRE, *to hear*

Pres. Ind.	**odo, odi, ode, udiamo, udite, ódonó**
Imperative	**odi, oda, udiamo, udite, ódano**

NOTE. **-u-** changes to **-a-** when the accent falls on the first syllable.

USCIRE, *to go away, out*

Pres. Ind.	**esco, esci, esce. usciamo, uscite. éscono**
Imperative	**esci, esca, usciamo, uscite, éscano**
Past Part.	**uscito**

Similarly : **ruiscire,** *to succeed*

VENIRE, *to come*

Pres. Ind.	**vengo, vieni, viene, veniamo, venite. véngono**
Past Def.	**venni, venisti, venne, venimmo, veniste. vénnero**
Future	**verrò, verrai,** etc.
Imperative	**vieni, venga, veniamo, venite, vEngano**
Pres. Subj.	**che io venga,** etc.
Past Part.	**venuto**

NOTE. **avvenire,** *to befall* : **convenire,** *to suit* : **divenire,** *to become* ; all similarly conjugated.

Aprire, *to open* ; has an irregular past definite **apersi.** Past Part. : **aperto.** Similarly : **coprire,** *to cover* ;

[1] This is one of the few verbs of which the alternative form is widely used. In some parts of Italy they say **BEVO,** in others **BEO,** etc.

offrire, *to offer* ; **soffrire,** *to suffer* ; **copersi, coperto ; offersi, offerto ; soffersi, sofferto.**

GENERAL LIST OF ESSENTIAL IRREGULAR VERBS

The following list of verbs, irregular only in the Past Definite and Past Participle, is for reference.

Infinitive	Present Indicative	Past Definite	Past Participle
ACCOGLIERE *to welcome*	accolgo	accolsi	accolto
ACCÓRRERE *to run up, hasten*	accorro	accorsi	accorso
AGGIUNGERE *to add*	aggiungo	aggiunsi	aggiunto
AMMETTERE *to admit*	ammetto	ammisi	amesso
APPARTENERE *to belong*	(conjugated like TENERE)		
APPRENDERE *to learn*	apprendo	appresi	appreso
APRIRE *to open*	apro	aprii (apersi)	aperto
ASCENDERE *to ascend*	ascendo	ascesi	asceso
ASCONDERE *to hide*	ascondo	ascosi	ascosto
ATTENDERE *to wait*	attendo	attesi	atteso
CHIEDERE *to ask*	chiedo (chieggo)	chiesi (chiedei)	chiesto
CHIUDERE *to shut*	chiudo	chiusi	chiuso
CÓGLIERE *to gather*	colgo	colsi	colto
COMPRENDERE *to comprehend*	comprendo	compresi	compreso
CONÓSCERE *to know*	conosco	conobbi	conosciuto
CONTRADDIRE *to contradict*	(like DIRE)		
CONVÍNCERE *to convince*	convinco	convinci	convinto
COPRIRE *to cover*	copro	coprii (copersi)	coperto
CORRERE *to run*	corro	corsi	corso
COSTRUIRE *to construct*	contruisco	costrussi	costrutto
CRÉSCERE *to grow*	cresco	crebbi	cresciuto
CUOCERE *to cook*	cuocio	cossi (cocei, cocetti)	cotto
DECÍDERE *to decide*	decido	decisi	deciso
DEDURRE *to deduce*	(like ADDURRE)		
DIFENDERE *to defend*	difendo	difesi	difeso
DIRÍGERE *to direct*	dirigo	diressi	diretto
DISCÉNDERE *to descend*	discendo	discesi	disceso
DISSUADÉRE *to dissuade*	dissuado	dissuasi	dissuaso
DISTRÚGGERE *to destroy*	distruggo	distrussi	distrutto
DIVIDERE *to divide*	divido	divisi	diviso
ECCEDERE *to exceed*	eccedo	eccedei	ecceduto
ELÉGGERE *to elect*	eleggo	elessi	eletto
ESCLÚDERE *to exclude*	escludo	esclusi	escluso
ESISTERE *to exist*	esisto	esistei	esistito
ESPRÍMERE *to express*	esprimo	espressi	espresso
ESTÉNDERE *to extend*	estendo	estesi	esteso
ESTÍNGUERE *to extinguish*	estinguo	estinsi	estinto
EVÁDERE *to evade*	evado	evasi	evaso
FIGGERE *to fix*	figgo	fissi	fitto (fisso)
FRÁNGERE *to smash*	frango	fransi	franto
GIÚNGERE *to arrive, reach*	giungo	giunsi	giunto
INCÉNDERE *to set light to*	incendo	incesi	inceso
INCLÚDERE / **INCHIUDERE** *to include*	includo / inchiudo	inclusi / inchiusi	incluso / inchiuso
INSÍSTERE *to insist*	insisto	insistei	insistito
INTÉNDERE *to understand*	intendo	intesi	inteso
INVÁDERE *to invade*	invado	invasi	invaso
LEGGERE *to read*	leggo	lessi	letto
METTERE *to put*	metto	misi	messo
MUOVERE *to move*	muovo	mossi	mosso
NEGLIGERE *to neglect*	negligo	neglessi	negletto
OCCORRERE *to be necessary*	(like CÓRRERE)		
OFFENDERE *to offend*	offendo	offesi	offeso
OFFRIRE *to offer*	offro	offrii (offersi)	offerto
OPPRÍMERE *to oppress*	opprimo	oppressi	oppresso
PERDERE *to lose*	perdo	perdei	perduto
PERMETTERE *to permit*	permetto	permisi	permesso
PERSUADERE *to persuade*	persuado	persuasi	persuaso
PIÁNGERE *to weep*	piango	piansi	pianto
PIOVERE *to rain*	piove	piovve	piovuto
POSSEDERE *to possess*	possiedo	possedei	posseduto
PRENDERE *to take*	prendo	presi	preso
PROTÉGGERE *to protect*	proteggo	protessi	protetto
RÁDERE *to shave, erase*	rado	rasi	raso
RENDERE *to give back*	rendo	resi	reso
RESÍSTERE *to resist*	(like INSÍSTERE)		
RICONÓSCERE *to recognize*	(like CONOSCERE)		
RIPRÉNDERE *to resume*	(like PRÉNDERE)		
RISPONDERE *to respond*	rispondo	risposi	risposto
ROMPERE *to break*	rompo	ruppi	rotto
SCÊNDERE *to descend*	scendo	scesi	sceso
SCÍNDERE *to separate*	scindo	scissi	scisso
SCOPRIRE *to discover*	scopro	scoprii	scoperto
SCRIVERE *to write*	scrivo	scrissi	scritto

SEDERE *to seat*	**siedo**	**sedei**	**seduto**
SOFFRIRE *to suffer*	**soffro**	**soffrii (soffersi)**	**sofferto**
SÓLVERE *to solve*	**solvo**	**solvei**	**soluto**
SOPPRÍMERE *to suppress*	(like **OPPRÍMERE**)		
SOPRÉNDERE *to surprise*	(like **PRÉNDERE**)		
SPÉNDERE *to spend*	**spendo**	**spesi**	**speso**
UCCÍDERE *to kill*	**uccido**	**uccisi**	**ucciso**
VÍNCERE *to vanquish*	**vinco**	**vinsi**	**vinto**
VIVERE *to live**	**vivo**	**vissi**	**vissuto**
VÓLGERE *to turn round*	**volgo**		**volto**

* Future **vivero, or vivrò.**

EXERCISE ON VERBS

Io parlo abbastanza bene l'italiano; da principio credevo che fosse più difficile del francese, ma mi sono sbagliato. L'ho studiato per due anni ed ora lo parlo senza difficoltà.

I speak Italian well enough , at the beginning I thought it was more difficult than French, but I made a mistake. I have studied it for two years and now I can speak Italian without any difficulty.

— **Ieri ero a Torino ed oggi sono qui a Roma ; spero che avrò il piacere di vederla alla conferenza che darò domani al Colosseo.**

—**Ben volentieri accetto il suo invito e porterò con me mia moglie e mio figlio. A che ora comincia ?**

- **Alle 10 antimeridiane ; non durerà più di un'ora.**

Non mi voglio dilungare di più ; son sicuro che troverà la mia conferenza interessante.

—**Grazie ancora una volta ; non mancheremo di essere puntuali all'adunata.**

The Passive of Verbs and Reflexive Verbs

—**Come lei sa sono stato chiamato al Parlamento.**

—**Me ne ricordo perfettamente e verrò a sentirla quando farà il suo discorso sulle pensioni. Si è detto che avremo la guerra fra non molto ma non ci credo.**

Impersonal Verbs

They are used only in the third person singular and as a rule they do not refer to a person.

Come fa freddo oggi ! e piove anche a dirotto; però bisogna che io esca lo stesso.

How cold it is to-day ! and it is also raining cats and dogs, but I must go out just the same.

Basta, ci vuol pazienza; sarebbe peggio se nevicasse !

Enough ! we must be patient, it would be worse if it was snowing !

The Subjunctive and its Uses

Supposto che non venga come farò ?

Supposing he does not come, what shall I do ?

- -**Grazie, venite a riprendermi alle undici e tre quarti per ritornare all'albergo. (Il signore entra nel Castello.)**

—**Ecco il mio permesso, potrei visitare il Castello ?**

Custode **Certamente, ecco appunto una guida che le sarà d'aiuto.**

· *Guida* **Sono a sua disposizione e prima di cominciare mi permetta di darle in succinto** (a summary) **l'origine di questa mole.**

- *Signore* · **Grazie di tutte queste informazioni ; son certo che la visita sarà molto interessante e siccome prevedevo che avrebbe preso molto tempo ho detto al cocchiere di venirmi a prendere qui alle undici a tre quarti e posporro la mia visita a S. Pietro per domani mattina. Cominciamo il giro !**

LESSON 8

Adverbs, Prepositions, Conjunctions, and Correspondence

THIS may seem a rather formidable lesson, but it is not. The adverbs, prepositions, and conjunctions and their usage are all straightforward and for the most part invariable. Hence this lesson is very largely a matter of learning words. And as some of these are the most frequently recurring words in the language, it is important to know them.

A few idioms are given the most useful -- to indicate the nature of Italian idioms, of which there is a great number. They will be learnt as they are encountered in reading, and there is no need to learn many at the present stage.

Correspondence in Italian is quite straightforward.

ADVERBS

An adverb is a word used to qualify any part of speech except a noun or pronoun.

Four simple rules enable one to form all the adverbs ever likely to be required, apart from those given in the list below.

Most English adverbs are formed by adding -LY to the adjective. The Italian **-mente** (f.) meaning *mind*, is used as equivalent ending. Thus, *cold, coldly* : **freddo, freddamente.** Hence:

Rules to Form Adverbs

(1) Add **-MENTE** to the *feminine singular* of the adjective . **freddo, freddamente.**

(2) When the adjective ends in **-e**, not preceded by **l** or **r**, simply add **-MENTE**:

felice, *happy* ; **felicemente**, *happily*.

(3) When the adjective ends in **-e** preceded by **l or r**, this **-e** is dropped ·

fácile, *easy* ; **facilmente**, *easily*,

and ·

(4) Use a preposition with a noun : **con amore**, *lovingly* (with love).

Comparison. Comparison follows the same principles as for adjectives. (*See* page 1816).

(1)	(2)
fácile, *easy*	**più fácilmente**, *easier*
caro, *dear*	**meno caramente**, *less dear*

(3)

il più fácilmente, *easiest*
il meno caramente, *least dear*

The superlative is sometimes formed merely by repeating the positive; **presto,** *soon*; **presto presto,** *very soon*; **piano piano,** *very softly.*

Irregular Comparisons. The following are examples of a few adverbs which are irregular in comparison:

bene, meglio, il meglio, *well, better, best*
male, peggio, il peggio, *badly, worse, worst*
poco, meno, il meno, *little, less, least*
molto, più, il più, *very, more, most*

A few useful adjectives are used as adverbs: **chiaro,** *clear*, **fisso,** *fixed, firm*; **spesso,** *frequent* **basso,** *deep, base*; **falso,** *false*; **certo,** *certain*; **sicuro,** *sure*, **mezzo,** *half*; **forte,** *strong, loud*; **piano,** *soft, low.*

Thus:

Esso parla chiaro, forte, piano, *He speaks clearly, strongly, softly.*

Now learn the following essential "invariable" adverbs. Note that the list includes few adverbs formed from adjectives by adding **-mente.**

LIST OF USEFUL ADVERBS

Section 1. Affirmation and Negation

SÌ, *yes*[1]	**NON—PUNTO,** *not at all*
infatti, *indeed*	**non—già,** *not—even*
CERTO, certamente, sicuramente, *surely, certainly*	**NON—PIÙ,** *not—any more, no longer*
DAVVERO, *truly, really*	**neanche, NEPPURE,** *not even*
SENZA DUBBIO, *undoubtedly*	**GIÀ,** *already, just now*
NO, *no*	**appunto,** *exactly (just) so*
NON, *not*	**non mica,** *not—certainly*
NÈ—NÈ, *neither—nor*	**NON—ANCORA,** *not—yet*
veramente, *truly*	**in nessun modo,** *by no means*
NON—CHE, *only*	
NON—MAI, *never*	

[1] Essential Adverbs are in large type

Section 2. Choice and Doubt

SOPRATTUTTO, *especially*	**FORSE,** *perhaps*
FINALMENTE, *finally*	**CIRCA,** *about*
PERCHÈ? *why?*	**PROBABILMENTE,** *probably*
PERCHÈ, *because*	**PIUTTOSTO,** *rather*
perciò, *that is why, however*	**prima di tutto,** *first of all*

Section 3. Adverbs of Place

DOVE, *where, whither*	**DIETRO,** *behind*
onde, donde, *where from, whence*	**indietro,** *behind, backwards*
QUI, qua, *here, hither, this way*	**SOTTO,** *below*
LÀ, LÌ,[2] *there, thither*	**A DESTRA, a diritta,** *on the right*
VI, CI (French y), *here, there*	**A SINISTRA, a manca,** *on the left*
SOPRA, SU, *on, upon*	**innanzi,** *before, forward*
DI SOPRA, *above, upstairs*	**davanti,** *before, forward*
DI SOTTO, *below, downstairs*	**AVANTI,** *forward, along*
da parte, *aside*	**dentro, entro,** *therein, within*
lassù, *up there*	**FUORI,** *outside, out*
GIÙ, *below, down*	**da per tutto, dappertutto, ognidove,** *everywhere*
laggiù, *down there*	
quassù, *up here*	
quaggiù, *down here*	**qualche luogo,** *somewhere*
in su, *upwards*	
in giù, *downwards*	**altronde, altrove,** *elsewhere*
abbasso, *down*	
DENTRO, *within*	**ovunque,** *wherever*

[2] N.B. qui (here) near the speaker lì, near the person spoken to; and là, away from both.

Section 4. Adverbs of Quantity

MOLTO, *much, very* (much)	**SOLTANTO, SOLO,** *only*
assai, *much* (enough)	**nonchè,** *also*
TROPPO, *too, too much*	**POCO,** *little*
TANTO, *so, so much*	**PIÙ, di più,** *more*
ABBASTANZA, *enough*	**MENO,** *less*
di più, (any) *more*	**QUANTO?** *how much?*
eziandio, *also, even, yet*	**TANTO—QUANTO,** *so much—as*
PURE, pur anco, *even, even yet*	**tanto più (meno),** *so much the more* (less)
SOLAMENTE, *only*	

Section 5. Miscellaneous Adverbial Expressions

a mente, a memoria, *by heart*	**ad alta voce,** *aloud*
in fretta, *in haste, hastily*	**ADESSO,** *now*
in furia, *in a hurry*	**adesso adesso,** *by and by*
invano, *in vain*	**fra breve,** *shortly*
con cómodo, *leisurely*	**a poco a poco,** *little by little*
a stento, *hardly, with difficulty*	**in breve,** *shortly*
di frequente, *frequently*	**per lo più,** *mostly*
di sólito, *generally, usually*	**a proposito,** *quite conveniently, by the bv.*
APPENA, *scarcely*	**a bocca,** *verbally, by word of mouth*
a buon mercato, *cheaply*	**tutt'al più,** *at the most*
a voce, *aloud*	**dapprima,** *first*
a posta, *on purpose*	**APPUNTO,** *exactly*
a caso, *by accident, chance*	

PREPOSITIONS

A preposition is a word placed before a noun to show in what relation the person or thing denoted thereby stands to something else. (For prepositions which form contractions with the article see pages 1812, 1813.)

a, *at*	**giusta,** *according to*
con, *with*	**in,** *in, within*
di, *of*	**per,** *for, by*
da, *of, from, by*	**secondo,** *according to*
avanti, *before*	**malgrado,** *notwithstanding*
contro, contra, *against*	**mediante,** *by means of*
	oltre, *besides, beyond*
verso, *towards*	**eccetto, salvo,** *except*
dopo, *after*	
durante, *during*	**senza,** *without*
fra, tra, *between*	**sopra,** *on, upon, over*
	sotto, *under*
lungo, *along*	**su (sur, in su),** *over, upon*

All other prepositions may be followed by **DI, A** or **DA.**

Prepositions generally followed by DI

Fuori (di), *out* (of), *outside*	**alla volta di,** *in the direction of*
al di là, *on the other side*	
al di quà, *on this side*	**a causa,** *by reason of*
al di sopra, *above*	**a ragione,** *on account of*
presso, *near*	**per,** *by*
a forza di, *by dint of*	**per mezzo,** *by means*
prima (of time), *before*	**in luogo, in vece,** *instead*
di sotto, *underneath*	
di dentro, *within*	**appiè,** *at the foot*
di fuori, *outside*	**a dispetto,** *in spite of*
a seconda di, *according to*	**in favore,** *in favour*

a modo, *in the manner*

Prepositions generally followed by A

Fino, *till, as far as*	**in rispetto, in quanto,** *concerning*
in faccia, *opposite*	
circa, incirca, *about*	**dietro, di dietro,** *behind*
in mezzo, *amidst*	**accanto,** *beside*
dentro, *inside*	**intorno,** *about*
innanzi, dinanzi, davanti, *before*	**vicino,** *near*
	conforme, *as*
	rincontro, *against, opposite*

attorno, *around, all round*

Prepositions generally followed by DA

lontano, **lungi**, *far*
fin da, *from*
in fuori, *except*

There are few reliable rules for the subtle usage of prepositions and the student is advised for a beginning to be satisfied with knowing the simple equivalents given above. He should, however, note carefully that **da** is the preposition of *agency*, *cause*, *fitness*, and *source*, thus:

Il ragazzo fu punito dal maestro, *The boy was punished BY the master.*
Essa fu soffocata dal fumo, *She was suffocated BY the smoke.*
Discende da poveri cittadini, *He is descended FROM poor citizens.*
Un uomo da bene, *An honest man.*
Un uomo da poco, *A good-for-nothing man*
Tira da suo padre, *He takes after his father.*
È una cosa da sorprendere, da ridere, da deplorare, *It is a surprising, laughable, deplorable thing.*
Egli dà da lavorare, da mangiare, *He gives work, the wherewithal to eat.*
Non è acqua da bere, *It is not water fit to drink.*
Vi parlo da amico, *I speak to you as a friend*
Ho da dirvelo, *I have to tell you.*

The preposition **di** is used for the English preposition *to* when prefixed to an infinitive preceded by another verb, as:

I promise you to come, **Vi prometto di venire.** *He has told him not to speak*, **Gli ha detto di non parlare.** *He was not afraid to say it*, **Non aveva paura di dirlo.** But, should the first verb imply motion, the preposition *to* is translated by **a**: *I am going to see Edward*, **Vado a vedere Eduardo.** *He has been to pay him a visit*, **È stato a fargli visita.**

The verbs **potere, sapere, dovere, volere, fare, lasciare, bisognare, bastare,** and **convenire** do not require a preposition before an infinitive which follows them:

Non potrò venire, *I shall not be able to come.*

CONJUNCTIONS

Conjunctions are words used for connecting words or sentences. For example: "You *and* I," "My brother *and* I are good friends, *but* he is much older than I."

And and *but* are the conjunctions.

In the following list the words in capitals are essentials:

SE, *if*
E PURE, **EPPURE**, *and yet*[1]
tanto-quanto, *as well as*
QUANDO, *when*
COME, *as*
finchè, *as long as*
DOPO CHE, *after*
APPENA, **a pena**, *scarcely*
SUPPOSTO CHE, *supposing, provided that*
ANCHE, *also*
allorchè, *then, when*
PERCHÈ, **poichè**, **giacchè**, **siccome**, *because, since, as*
posciachè, *after that, since*
O, *or* (od before a vowel)
O—O, *either—or*
ovvero, **oppure**, *or*
benchè, **sebbene**, **ancorchè**, *though, although*
però, **pertanto**, *however, yet*
NÈ—NÈ, *neither—nor*
ora—ora, *now—now*
CHE, *that*
MA, *but*
E, *and* (ed before a word beginning with a vowel)
sicchè, *so that*
AFFINCHÈ, *so that, in order to*
PRIMA CHE, *before, sooner*
quand'anche, *although*
se anche, *even if*
di maniera che, **di modo che**, *so that*
tosto che, **súbito che**, *as soon as, at the time*
PERÒ, *though, however, therefore*
DUNQUE, *so, therefore*
quindi, *therefore, consequently*
dacchè, *because, since*
MENTRE, *whilst*
fin a tanto che, *as long as*
ANZI, *on the contrary, even*
NEPPURE, *not even*
SENZA CHE, *without*
MA ANCHE, *but also*
non ostante che, *notwithstanding*
per quanto, *however*
non perciò, *nevertheless*
nullameno, **nientemeno**, *nevertheless*
per altro, *however*

—and the following which must always be used with the subjunctive of the verb:

affinchè, *in order that*
a meno che, *unless*
a patto che, *on condition that*
benchè, *although*
comecchè, *as if*
dato che, *given that*
nel caso che, *in case that*
nonostante che, *notwithstanding that*
posto che, *granted that*
prima che, *before*
purchè, *provided that*
qualora, *if*
quandanchè, *even if*
quandochè, *even when*
sebbene, *though*
semprechè, *always granted that*

[1] The student will notice that in the lists of adverbs, prepositions and conjunctions he will find words repeated. The distinction between a word used as an adverb, preposition, and conjunction is a grammatical subtlety. If the *word* is known, that is sufficient for the present.

INTERJECTIONS

Interjections are words used to express a feeling or emotion, as for example:

joy, **bene! bravo! viva!**
sorrow, **ahi! ohi! ahimè! ohimè!**
silence, **zitto!**
wish, **magari!**
doubt, **mah!**
disdain, **oibò!**
surprise, **oh!**
fear, **uh! guai!**

Ecco, *here is, here are*, may be joined to a pronoun: **eccomi**, *here I am*, **eccoli**, *here they are*; **eccone**, *here is some of it.*

NOTE. **ADDIO!** *adieu!* **ARRIVEDERCI!** *good-bye!* **ben arrivato!** *welcome*

IDIOMS

Italian is rich in idioms, and they must be learnt by experience rather than from books. But here are some elementary and essential idioms which must be known:

avere appetito, *to be hungry*
avere ragione, *to be right.*
chiamarsi, *to be called, named*
avere caldo, *to be hot*
mi piace —, *I like—*
non mi piace —, *I do not like—*
Davvero? *Really?*
Da quanto tempo? *How long since?*
Sono nato il —, *I was born on—*
Quante volte? *How often?*
di nuovo, *again*
avere fretta, *to be in a hurry*
avere sete, *to be thirsty*
avere torto, *to be wrong*
Come si chiama lei? *What is your name?*
avere freddo, *to be cold*
niente affatto, *not at all*
a me pure, *I also, to me also*
nemmeno io, lui, *Not I, he*, etc.
Che c'è di nuovo? *What news?*
Lo faccia di nuovo, *Do it again!*
di più, *most, the best*
Questo è che mi piace di più, *That is what pleases me best, most*
Come sta lei? *How are you?*

Lungo, largo, and **alto** are used for *length, breadth* and *height*: **Questa stanza è lunga 10 piedi, larga 20 ed alta 8**, *This room is 10 feet long, 20 broad* (or wide), *and 8 high.*

CORRESPONDENCE

The date is written thus: **3 Gennaio 1958: 2 Marzo 1958,** etc., but the first of a month is always 1° (representing **primo,** the ordinal number).

In Italian commercial correspondence the opening salutation (Dear Sir, Madam, etc.) is generally omitted, and this applies to most formal correspondence. When the correspondence is informal then Dear Sir, Madam, etc. may be expressed as follows:

(*a*) when the name of the person addressed is added:

Egregio Signor Colaluca
Pregiato Signor Colaluca } *Dear Mr. Colaluca*

(*b*) when the name of the person addressed is omitted:

Egregio Signore
Pregiato Signore } *Dear Sir*

—or one may say **Stimato Signor Colaluca, Stimato Signore**—

To a lady one writes:

Gentilissima Signora, or
Gentilissima Signorina

—adding her name, if on terms of friendship.

A very familiar opening is: **Caro mio,** or **Cara mia;** or **Mio caro amico, Cara amica mia.** The beginner should be careful about using these openings.

ENDINGS: The endings for letters in Italian are elaborate, and the student is advised to keep to the following:

Familiar. **Devotissimo suo,** *Yours very sincerely*
Formal: **Colla massima stima, vi saluto,** *Yours faithfully*

NOTE. In commercial correspondence, the second person plural is used, and, as the opening and ending formulae are somewhat elaborate, the student must refer to a book dealing with this aspect of the subject.

In addressing an envelope write:

Egregio Sig. Colaluca, or
Gentilissima Signora Colaluca.

C/o is expressed by the word **Presso.**

EXERCISES ON ADVERBS, PREPOSITIONS, etc.

Il parlare e l'agire francamente sono le caratteristiche dell'uomo integerrimo.

To speak and act frankly are the characteristics of an honest man.

Si vede chiaramente che ciò non è vero e sarà meglio che io mi occupi di questa faccenda.

One can see clearly that this is not true and it will be better if I see to this business.

Questo ragazzo è il più intelligente che io abbia mai incontrato; davvero non l'avrei mai creduto; non ho ancora inteso come sia andato il suo esame, ma son sicuro che è passato con lode (with praise). **Avrebbe piuttosto dovuto imparare l'inglese che il francese; non fa niente imparerà l'inglese più tardi.**

Prepositions

Al di là del fiume dimora un vecchietto che sta sempre seduto accanto alla porta della sua capanna, e sembra sempre soddisfatto e contento a dispetto della sua povertà. Non bisogna però giudicare sempre dall'apparenza. Mi prometto di andarlo a vedere appena posso e fare la sua conoscenza.

Parla l'inglese fin da quando era bambino; adesso studia l'italiano e per il momento non ne sa molto; bisogna fare grande attenzione per capire quel che dice.

Conjunctions

Faccia come crede; appena potrà però non si dimentichi di mandarmi il contratto. In quanto al resto ne parleremo un'altra volta (another time), **benchè sarebbe stato meglio di decidere adesso la questione una volta per sempre.**

Supposto che le presti quel che mi chiede che cosa ne farebbe di questo denaro?

Quando si è sentita la gioia di un popolo per il rifiorire della pace, ci sembra incomprensibile che questa non possa durare . . . eppure . . . si direbbe che il cuore dell'uomo non la meriti, poichè non pare che gli bastino le tribolazioni che ci sono già sulla terra senza cercarsene delle altre ancora. Spesso dopo che il male è fatto, dopo che gli avvoltoi della terra si sono sfamati, si piange ma è inutile far da coccodrillo, le vittime sono già divorate.

Interjections

—**Guarda chi si vede! Bene! Bravo! sono proprio contento che sia venuto a vedermi; per solennizzare la sua venuta che ne dice se le offro un buon bicchiere di Chianti?**

—**Magari! mi farà gran piacere.**

—Look who is coming! Good! Bravo! I am very pleased that you came to see me, to commemorate your coming I am going to offer you a glass of good Chianti. What do you say?

—Rather! It will give me great pleasure.

Ecco che lei vuol scappar via! Perchè non restare ancora un pò; in questo frattempo mia moglie potrebbe ritornare e vorrei che la vedesse prima di andarsene.

—Here, you already want to run away, why not remain a little while longer, my wife might meanwhile return and I should be pleased if you saw her before leaving.

Idioms

—**Le ripeto che ho ragione; nemmeno lei può darmi torto.**

I repeat that I am right; not even you can say that I am wrong.

—**Ho tanta fretta adesso; mi lasci andare. Non mi piace di essere in ritardo ai miei appuntamenti.**

—I am now in a hurry; let me go as I do not like to be late for my appointments.

Avevo una fame da lupo quando arrivai a casa.

I was as ravenous as a wolf when I got home.

Come si chiama lei?

What is your name?

Correspondence

Napoli 24 Febbraio 1958

Egregio Sig.r Stefanini,

In risposta alla sua stimata del 10 corr. mi pregio rimetterle qui accluso un assegno bancario di £15 0 0 (Quindici sterline) a saldo del suo avere.

La prego di volermene accusare ricevuta e con distinti saluti, mi creda,

Suo Dev.mo
R. Giuliani.

Roma li 20 Dicembre 1958

Carissimo fratello,

La tua lettera mi ha fatto molto piacere. Son contento di sentire che state tutti bene di salute e che verrete a passare le feste Natalizie con noi. Non dimenticare di farmi sapere il giorno che arrivate in modo che possa farvi trovare tutto pronto per la vostra visita. Saluti affettuosi a tua moglie, baci ai bambini, ed a te una sincera stretta di mano dal

Tuo aff.mo fratello
Giovanni.

LESSON 9

Practice in Conversation

THE student has been given in the first eight Lessons a general basis for the comprehension and use of Italian nouns, adjectives, pronouns, verbs, adverbs, prepositions, conjunctions, etc., with exercises in their written use. He has accordingly, if he has followed the advice given for practice and second perusal in certain instances, obtained a fair grounding in Italian grammar. He should now, remembering the injunctions given in Lesson I, use the material that follows for actual conversational exercises.

Alla Galleria Nazionale

Signor dei Tali:[1] Non facciamo che dire di andar a vedere qualche cosa; e ora che ci decidiamo Andiamo a vedere dei quadri?

Amica: Io invece vorrei andare a vedere Mickey Mouse.

Signor dei Tali: No, ho detto dei quadri, non il Cinema.

Amica: Per me fa lo stesso. Ecco un taxi nuovo.

Signor dei Tali: Eccoci arrivati! Da che porta si entra oggi?

Amica: Vi sono parecchie porte?

Signor dei Tali: Sì, oggi non sis entra gratis. Lei entri qui, la raggiungo in un minuto. Io entro gratis Ecco sei pence per lei.

Custode: Vuol firmare il libro Signore? Gli ombrelli a sinistra, Signorina.

Signor dei Tali: Lo metta col mio bastone, tanto usciremo insieme.

Amica: Abbiamo tempo di veder tutto?

Signor dei Tali: Forse no, ma sarà meglio vedere una o due cose speciali prima che ci stanchiamo troppo.

Amica: Quali dobbiamo veder prima?

Signor dei Tali: Ebbene, siccome fa tanto caldo, andiamo prima nella Sala dei Pittori italiani i quadri veneziani sembrano più belli alla mattina presto.

Amica: Oh! guardiamo queste cose curiose nel pavimento.

Signor dei Tali: Va bene - sono state fatte da un mio amico.

Amica: Che rappresentano?

Signor dei Tali: Non ne sono certo. Però non è inglese. I conoscitori dicono che sia bravo.

Amica: Non si cancelleranno col camminarvi sopra?

Signor dei Tali: Non ce' pericolo.

Amica: Che è quel quadro sopra la porta?

Signor dei Tali: Si dice che sia di Michelangelo, ma vediamo prima quegli altri in faccia.

Amica: Voglio comprare una o due cartoline colorate da mandare alle mie amiche.

Signor dei Tali Bene, mentre sceglie le cartoline, vado adire qualche parola al custode ed a domandargli se c'è qualche cosa di nuovo.

Custode: Come sta, Signore? Qualche cosa di nuovo? Ebbene, hanno portato via uno o due quadri per pulirli ed al loro posto han messo dei quadri che stavano nel deposito. Il Signor Giovanni era qui poco prima di lei. È andato giù per di là con due bellissime ragazze.

Signor dei Tali: Lo si vede qui spesso?

Custode: Di quando in quando. È un bravo pittore, non è vero Signore? ma ora non fanno niente come la vecchia scuola.

Amica Neho comprate molto più del necessario. È tanto difficile di deci ersi! Possiamo vedere questo qui?

Custode: Sì, Signorina—Sala XV a sinistra. Seguino quella Signora vestita di bianco. Essa viene qui per farne delle copie.

Signor dei Tali: Bene, credo di sapere dove è.

Amica: Che uomini strani si vedono qui. Guardi quel contadino che dorme sopra al giornale.

Signor dei Tali: Ma quello non è un contadino. Viene da Oxford e sta ora scrivendo un libro sull'effetto dei colori.

Amica È Scienza o Arte quella?

Signor dei Tali: Egli è probabilmente più interessato nella Scienza

Amica: Egli sta facendo certamente buon uso del suo tempo In ogni modo i giornali dicono che le mosche non si posano mai su qualche cosa di giallo.

Signor dei Tali: Che gliene pare di queste copie? Alcune di esse non sono affatto come i quadri.

Amica: Non sia cattivo! ve ne sono alcune assai buone.

Signor dei Tali: Ebbene, in che consiste il loro merito?

Amica: Quella lì, per esempio, sembra vivente Relativamente, forse, non è proprio giusta, ma è piena di sentimento.

Signor dei Tali. Probabilmente Vedo il suo punto di vista.

Amica. È inutile giudicarle come lavori d'arte, ma per quel che sono, fanno piacere a vederle.

Signor dei Tali: Ebbene, fino ad ora non abbiamo veduto nemmeno un quadro. Andiamo a vedere Raffaello?

Amica Come vuole, ma sembra aver tanto poco in comune con noi.

Signor dei Tali. Che cosa suggerisce allora?

Amica: Hanno tutti il loro merito, ma Michelangelo mi piace più degli altri.

Signor dei Tali Si trovano quasi insieme, così potremo vederli tutti e due.

Amica: Da che parte si va?

Signor dei Tali: Voltiamo da questa parte; vicino alla ringhiera, così non sarà necessario di discendere i gradini. (Voltiamo, *let us turn.*)

Custode. Fuori tutti! Fuori! Da questa parte Signori e Signore!

Amica. Che noioso! (*What a nuisance!*)

Signor dei Tali: Ricavano molto piacere da tutto questo; probabilmente ciò dà loro un'aria militare. Si direbbe che son pronti ad infilarvi col coltello.

Amica: Non fa nulla: saremo fuori prima.

Signor dei Tali: Aspetti un momento, ecco una bella testa romana.

Custode: Fuori tutti per favore! Avanti, avanti, Signore.

Signor dei Tali: Un momento, per Bacco!

Custode: Tutti fuori! La campana è già suonata!

Amica. Mi dia dunque la contromarca ed andrò a prendere il mio ombrello, mentre lei dà un'occhiata in giro. (*A look round.*)

Signor dei Tali: (sui gradini) Ci si stanca molto in questi posti.

Amica: Sì, è vero, ma è tanto bello quando si esce sulla Piazza di Trafalgar!

Signor dei Tali: Piove!

Amica: Davvero!

[1] Signor dei Tali—Mr. Everyman Mr. So-and-So.

LESSON 10

The Essential Vocabulary of Italian

In order to express more than 90 per cent. of the ideas of everyday life, a vocabulary of about 1,150 words is necessary in Italian. The student must master the pronouns, the numbers; certain adverbs, prepositions, conjunctions, and interjections; the names of the days of the week, the months of the year, a few common idioms and the proper names, and the vocabulary in the alphabetical list given below. This represents the essential vocabulary of the language which, used in accordance with grammar, provides the student with a working vocabulary of several thousand words, and will enable him or her to pick up the average Italian newspaper or book, confident that most of it can be understood.

It has been ascertained that a beginner can memorise anything from 10 to 30 or 40 new words of a foreign language in an hour; after a few hours' practice the number increases. The Essential Vocabulary of Italian, and the general principles of the grammar, can be assimilated in a few months. Those students who know Latin or one of the Romance languages, will learn more rapidly than those who do not. All will find that Italian contains a large number of words which greatly resemble their English equivalents, and are assimilated with little effort.

Know the vocabulary BOTH WAYS: **l'uomo,** *the man*; *the man*, **l'uomo.** Speak words aloud when memorising them. Thus from the very beginning of the learning process, repeat the word with its equivalent both ways until it is recognizable both ways, and by *sight* and by *sound.* Repetition should be continued until meaning and pronunciation come without hesitation. AS EACH WORD IS BEING MEMORISED AN IMAGE OF THE THING OR AN ASSOCIATION OF THE IDEA SHOULD BE IN THE MIND. This not only facilitates learning by making it more interesting, but it accustoms the learner *to think* in Italian. So, when learning the Italian word **città,** *city*, think of the city with which you are most familiar, its streets, houses, people, and traffic. The more the imagination is used to assist memory in this way, the more rapid will be the progress in the language.

See statistical note at the end of the course.

THE ESSENTIAL VOCABULARY

Days of the Week, Months, Seasons, and Proper Names

1. Days of the Week

Lunedì, *Monday* — **Giovedì,** *Thursday*
Martedì, *Tuesday* — **Venerdì,** *Friday*
Mercoledì, *Wednesday* — **SAbato,** *Saturday*
DomEnica, *Sunday*

(All masculine except the last)

2. Months of the Year

Gennaio, Febbraio, Marzo, Aprile, Maggio, Giugno, Luglio, Agosto, Settembre, Ottobre, Novembre, Dicembre.

3. Seasons

la primavera, *spring* — **l'autunno,** *autumn*
l'estate (masc.), *summer* — **l'inverno,** *winter*
la stagione, *the season.*

4. Points of the Compass

Nord, *North* — **Est,** *East*
Sud, *South* — **Ovest,** *West*

5. Proper Names and Adjectives

L'Europa, *Europe* — **europEo,** *European* (-a, -*woman*).
L'Italia, *Italy* — **italiano,** *Italian*
L'Inghilterra, *England* — **inglese,** *Englishman*
La Francia, *France* — **francese,** *Frenchman*
La Germania, *Germany* — **tedesco,** *German*
La SvIzzera, *Switzerland* — **svIzzero,** *Swiss*
La Spagna, *Spain* — **spagnOlo,** *Spanish*
Il Portogallo, *Portugal* — **portoghese,** *Portuguese*
La Russia, *Russia* — **russo,** *Russian.*
Gli Stati Uniti, *the U.S.(A.)* — **americano,** *American*
La Gran Bretagna, *Great Britain.*

Londra, *London* **Parigi,** *Paris* **Berlino,** *Berlin* **Roma,** *Rome* **Torino,** *Turin* **NApoli,** *Naples* **GEnova,** *Genoa* **Firenze,** *Florence* **VenEzia,** *Venice* **Milano,** *Milan* **Livorno,** *Leghorn* **Le Alpi,** *The Alps* **La MAnica,** *The English Channel* **Il MediterrAneo,** *The Mediterranean*

ALPHABETICAL LIST OF ITALIAN WORDS

The following alphabetical list is for repetition and reference. Words in BOLD CAPITALS should be learnt first, as they are essential; the remainder can be approached later. Stress is indicated either by an accent or by printing the stressed letter in a distinctive type.

A

ABBASTANZA, *enough*
abbisognare, *to be necessary*
abbondare, *to abound (in)*
abbreviare, *to abridge, shorten*
ABILE, *clever, skilful*
ABILITÀ, *ability, skill*
ABITO, *dress, clothes, costume, habit*
ABITUARSI, *to accustom oneself*
abominare, *to hate, abominate*
accadEmia, *academy*
ACCADERE, *to happen*
accEndere, *to set on fire, light*
accento, *accent*
ACCETTARE, *to accept*
ACCIAIO, *steel*
ACCIDENTE (m.), *accident, chance, misfortune*
ACCÓGLIERE, *to gather, welcome, receive with good will*
accomodare, *to accommodate*
ACCOMODARSI, *to sit down, be at ease*
ACCOMPAGNARE, *to accompany*
accordare, *to accord, grant*
accordarsi, *to agree (with)*
ACCORDO[1], *accord, agreement* (harmony)
accorgErsi, *to notice (with* shrewdness)
ACCOSTUMARE, *to accustom*
ACCOSTUMARSI, *to be used to*
accumulare, *to accumulate, heap up*
ACCURATO, *accurate*
accusare, *to accuse*
ACQUA, *water*
ADAGIO, *slowly, softly*
ADDIO, *adieu, farewell*
ADDIZIONE, *addition* (bill)
addormentarsi, *to fall asleep*
adoperare, *to employ* (in work)
AEREO, *aerial*

[1] **D'accordo!** *Agreed!*

affannare, *to grieve* (*about*)
affanno, *grief, anxiety*
affare, *affair, business*
affermare, *to affirm*
affezionarsi, *to become attached to, to like*
affezionato, *fond, affectionate*
AFFISSO, *fixed, attached to*
AFFRETTARSI, *to hurry*
AGENTE, *agent*
aggiUngere, *to join to, add, reach*
aggiunto, *added, attached to*
aggiustare, *to adjust*
AGGRADEVOLE, *agreeable, pleasant*
agiato, *at ease, rich*
AGIO, *ease, comfort*
AGUZZO, *sharp, edged*
AIUTANTE, *assistant*
AIUTARE, *to assist*
AIUTO, *assistance*
ALA, *wing*
albergo, *hotel, inn*
álcool, *alcohol*
ALIENO, *alien, foreign*
ALIMENTO, *nourishment, food*
allarme (m.), *alarm*
allegrIa, *happiness*
ALLEGRO, *gay, cheerful*
altezza, *height*
ALTO, *high*
alzare, *to lift, raise*
alzarsi, *to get up, rise*
amAbile, *lovable*
AMARE, *to love, be fond of*
amarezza, *bitterness*
AMARO, *bitter*
ameno, *pleasing, charming*
AMICO, *friend*
AMISTÀ, *friendship*
AMMALATO, *sick*
ammazzare, *to kill, murder*
ammEttere, *to admit, grant*
amministrare, *to administer*
ammirare, *to admire, envy*
AMORE (m.), *love*
ANDARE, *to go, walk*
andArsene, *to go away, to get out of*
anello, *ring*
ANGOLO, *angle, corner*
angusto, *narrow*
anima, *soul, spirit*
ANIMALE, *animal*
ANIMO, *mind, intelligence*
annesso, *annexed*
ANNO, *year*
annoiArsi, *to get annoyed*
annuale, *annual*
annunziare, *to announce*
ansietà, *anxiety*
ansioso, *anxious, eager*
antichità, *antiquity*
antico, *antique, old*
antipAtico, *disagreeable*
anziano, *ancient*
APERTA, *hole, opening*
APERTO, *open, evident*
apparato }
APPARECCHIO } *apparatus, what is seen, show, preparation*
APPARTENERE, *to belong to, to concern*
APPETITO, *appetite*
applaudire, *to applaud*
applauso, *applause*
applicare, *to apply*
applicarsi, *to apply, devote oneself to*
appoggiare, *to lean*
—**si** (*against*)
apprEndere, *to learn* (also *to teach*)
appuntare, *to point, sharpen*
APPUNTO, *precise* (*-ly*)
APRIRE, *to open*
arancio, *orange*
arbitrare, *to arbitrate*
architetto, *architect*
arco, *bow, arch*
arcuato, *arched, curved*
ARENA, *sand.*
ARGENTO, *silver*
ARIA, *air*
Arico, *arid, dry*
aritmEtica, *arithmetic*
ARME (f.), *weapon, arms*
ARRIVARE, *to arrive*
ARRIVO, *arrival*
arrostire, *to roast*
ARTE (f.), *art, skill*
artIcolo, *article*
artista, *artist*
ascEndere, *to ascend, mount, go up*
ASCOLTARE, *to listen* (*to*)
Asino, *ass, donkey*
ASPETTARE, *to expect, hope for*
assalto, *assault*
asse (m.), *axis*
assegno, *assignment, order*
assemblEa, *assembly*
ASSENTARSI, *to absent oneself*
assente, *absent*
assenza, *absence*
assicurare, *to assure*
assiso, *sitting, seated*
ASSISTERE, *to be present*
assoluto, *absolute*
assunto, *undertaking*
assurdo, *absurd*
astro, *star, heavenly body*
astuto, *astute, crafty*
atmosfera, *atmosphere*
attento, *attentive*
ATTENZIONE, *attention*
attirare, *to attract, draw to*
ATTIVITÀ, *activity*
attivo, *active, lively*
ATTO, *act, action*
attOnito, *astonished*
attore,[1] *actor*
ATTRATTIVO, *attractive*
ATTRAVERSARE, *to cross, traverse*
ATTUALE, *actual, real, present*
AUDACE, *audacious, brave*
AUMENTARE, *to increase, augment*
ausilio, *help*
austero, *austere, stern*
automObile (f.), *automobile*
autore, *author*
AUTORITÀ, *authority*
AVANTI, *before, sooner, forward!*

[1] Fem attrice, *actress.*

AVANZARE, *to advance*
avaro, *avaricious, greedy*
AVERE, *to have*
Avido, *avid, greedy*
avo, *grandfather*
avvantaggio, *advantage*
avventurarsi, *to risk*
AVVERTIRE, *to warn, advise of*
avvisare, *to inform*
AVVISO, *advice, notice*
avvocare, *to plead*
avvocato, *advocate, lawyer*
AZIONE, *action, deed*
azzurro, *azure, light blue*

B

baciare, *to kiss*
bAcio, *kiss*
bagaglio, *baggage*
bagnarsi, *to bathe, take a bath*
BAGNO, *bath*
baia, *joke*
balbutire, *to stammer*
BALENO, *lightning*
balla, *ball*[2]
balza, *rock, cliff*
bambino, *baby*
BANCA, *bank*
banchiEre, *banker*
BANCO, *bench, seat*
banda, *band, troop*
bandiera, *banner*
BARBA, *beard*
barbiere, *barber*
barbuto, *bearded*
BASE (f.), *base, basis*
BASSO, *low, mean, base*
BASTA, *enough*
bastante, *sufficient*
bastone (m.), *staff, stick*
battaglia, *battle*
BATTERE, *to beat*
baule (m.), *trunk, box*
beato, *blessed*
BELLEZZA, *beauty*
bellicoso, *martial, warlike*
BELLO, *beautiful, handsome*
BENAVVENTURATO, *lucky*
benedetto, *blessed*
benefattore, *benefactor*
beneficio } *benefit,*
BENEFIZIO } *kindness*
berretta, *cap*
bestia, *beast*
BEVERE (or bere), *to drink*
BIANCO, *white*
biblioteca, *library*
bicchiere (m.), *beaker, glass*
bigio, *grey*
biglietto, *ticket*
bilancia, *balance, scale*
biondo, *blond, fair*
birra, *beer*
bisavo, *great-grandfather*
bisbiglio, *whisper*
biscotto, *biscuit*
bisogna, *business, affair*
BISOGNARE, *to be necessary*
BISOGNO, *want, need*
bisognoso, *needy*
bistorto, *crooked, deceitful*
BIZZARRO, *odd, fantastic*

[2] ballo, *dance.*

blando, *bland, soft*
BOCCA, *mouth*
bollire, *to boil*
bollo, *seal, stamp*
bordo, *border*
borgo, *borough*
BORSA, *purse, exchange*
BOSCO, *wood, forest*
BOTTEGA, *shop*
BOTTIGLIA, *bottle*
BRACCIO, *arm*
bravare, *to defy*
BRAVO, *able, skilful*
bravura, *skilfulness*
breccia, *breach*
BREVE, *brief* (*-ly*)
brevità, *brevity*
brigatà, *brigade*
brillante, *brilliant*
brillare, *to glitter*
brIndisi, *toast, health*
BRIO, *vivacity*
bronzo, *bronze*
bruciare, *to burn* (int.)
BRUNO, *brown*
brusco, *rough*
BRUTO, *brute*
BRUTTO, *ugly*
BUCA, *hole, hollow*
bUe[3] (m.) (also **bOve**), *ox*
BUGIA, *lie, falsehood*
bugiardo, *liar*
BUONO, *good, kind*
BURLA, *trick*
BURLARE, *to jest*
burlesco, *burlesque*
burrasca, *tempest*
BURRO, *butter*

C

cacciare, *to hunt, chase*
cacciatore, *hunter*
cadenza, *fall, cadence*
CADERE, *to fall*
caduco, *frail*
caduta, *fall* (n.f.)
CAFFÈ, *coffee, coffee-house*
CAGIONE (f.), *cause, reason*
calamità, *calamity*
calca, *crowd*
calce (f.), *chalk, lime*
CALCOLARE, *to calculate*
cAlcolo, *calculation*
CALDO, *hot*
calendario, *calendar*
CALORE (m.), *heat*
calvo, *bald*
calza, *stocking*
calzoni (plur.), *trousers*
CAMBIARE, *to change*
CAMBIO, *change, exchange*
CAMERA, *chamber, room*
cameriere, *waiter*
cameriera, *maid, waitress*
camicia, *shirt*
CAMMINARE, *to travel, walk*
CAMMINO, *way, journey, road*
CAMPAGNA, *country*
campagnolo, *countryman*
CAMPO, *field*
canaglia, *rabble*
canale (m.), *canal*

[3] Note: carne di bue, *beef*

CANE, *dog*
CANTARE, *to sing*
cantatore, *singer*
CANTO, (1) *song, singing*, (2) *side, corner*
CAPACE, *capable*
capacità, *capacity*
capello, *single hair*
CAPELLI, *hair* (of the head)
CAPIRE, *to understand* (also *to be capable of containing*)
CAPITALE, *capital*
capitano, *captain*
capItolo, *chapter*
CAPO,[1] *head, beginning, chief, leader*
capolavoro, *masterpiece*
cappello, *hat*
CARATTERE, *character, disposition*
CARBONE (m.), *coal*
cArcere (m.), *prison*
carestia, *dearth, famine*
cArica, *charge, load*
caricare, *to charge, to load*
carità, *charity*
CARNE (f.), *flesh, meat*
CARO, *dear, beloved*
CARRO, *car*
carrozza, *coach*
CARTA, *paper, card*
CASA, *house, family*
caserma, *barrack*
CASO, *case, chance, event*
CASSA, *chest, moneybox*
castello, *castle*
casto, *chaste*
CATENA, *chain*
cattedrale, *cathedral*
CATTIVO, *wicked, bad*
CAUSA, *cause*
causare, *to cause*
cautela, *caution, bail*
cavaliere,[2] *knight, horseman*
CAVALLO, *horse*
cavità, *cavity*
CAVO, *hollow*
cecità, *blindness*
CELEBRE, *famous*
cena, *supper*
cEncio, *rag*
cEnere (f.), *ashes, cinders*
cenno, *sign*
censura, *censure*
centEsimo, *hundredth part*
centro, *centre*
centuria, *century, company of* 100
cera, *wax, wax-candle*
CERCARE, *to seek*
cErchio, *circle*
certezza, *certainly*
CERTO, *certain (-ly)*
cervello, *brains*
cesta, *basket*
cheto, *quiet*
CHIAMARE, *to call*
chiarezza, *clearness*
CHIARO, *clear, bright*
CHIAVE (f.), *key*
CHIEDERE, *to demand*
chiesa, *church*
chiesta, *demand, request*
CHIMICA, *chemistry*
chimico, *chemist* (also adj. *chemical*)
chinare, *to bend, incline*
chino, *bent, stooped*
chiodo, *nail*
chirurgo, *surgeon*
chiUdere, *to close, enclose*
CHIUSO, *closed, shut*
cibare, (trans.) *to feed*
CIBO, *food, nourishment*
cicatrice (f.), *scar*
CIECO, *blind*
CIELO, *heaven, sky*
cifra, *cipher*
cilindro, *cylinder*
CIMA, *summit*
cimitero, *cemetery*
CIRCOLO, *circle, ring*
CIRCOSTANZA, *circumstance*
citare, *to cite*
CITTÀ, *city, town*
cittadino, *citizen*
civile, *civil* (of a city)
classe (f.), *class*
cliente, *client*
CLIMA (m.), *climate*
coda, *tail*
CÓGLIERE, *to gather*
cognato, *kindred, brother-in-law*
collegio, *college*
cOllera, *anger*
COLLEZIONE, *collection*
collina, *hill*
collo, *neck, summit*
colonia, *colony*
colonna, *column*
COLORE (m.), *colour*
COLPA, *fault*
COLPO, *blow, stroke*
COLTELLO, *knife, table knife*
COLTO, *cultivated, cultured*
COMBATTERE, *to fight*
combinazione, *combination*
CÓMICO, *comical*
COMINCIARE, *to begin*
COMMEDIA, *comedy*
COMMERCIANTE, *merchant*
COMMERCIO, *trade*
CÓMODO, *convenient*
COMPAGNIA, *company*
composizione, *composition*
compra, *purchase*
COMPRARE, *to buy*
comprEndere, *to comprehend, understand*
comUne, *common, ordinary*
concerto, *concert, agreement*
condizione, *condition*
condotta, *conduct*
condUrre, *to conduct*
confessare, *to confess*
CONFIDARE, *to trust*
CONFIDENZA, *confidence*
CONFORME, *conformable, conformably*
CONFUSO, *confused*
congresso, *congress*
connEttere, *to connect, join*
CONOSCENZA, *acquaintance, knowledge*
CONÓSCERE, *to know*
CONOSCIUTO, *known*
CONQUISTA, *conquest*
CONQUISTARE, *to conquer*
CONSEGUENTE, *following*
CONSEGUENZA, *consequence*
CONSEGUIRE, *to obtain*
consentire, *to consent*
considerare, *to consider*
consigliare, *to advise*
CONSIGLIO, *counsel, advice*
consistere, *to consist*
consultare, *to consult*
consumare, *to consume*
contante (danaro), *ready money*
CONTARE, *to count*
CONTATTO, *contact*
CONTENTO, *content*
CONTENUTO, *contained*
CONTINUARE, *to continue*
CONTINUO, *continuous*
CONTO, *account, story*
contraddire, *to contradict*
CONTRARIO, *contrary*
contrasto, *contrast*
contrattempo, *misfortune*
contratto, *contract*
controllo, *control*
CONVERSAZIONE, *conversation*
convito, *banquet*
COPIA, *copy*
coppia, *couple*
CORAGGIO, *courage*
corda, *cord*
coro, *chorus, choir*
corona, *crown*
CORPO, *body*
corrente, *current*
CORSO, *course*
corte (f.), *court, courtyard*
cortina, *curtain*
CORTO, *short*
COSA, *thing*
COSTARE, *to cost*
costume (m.), *custom*
credenza, *belief*
CREDERE, *to believe*
CREDITO, *credit*
crema, *cream*
crEscere, *to grow*
crisi (f.), *crisis*
criticare, *to criticize*
CROCE, *cross*
crudEle, *cruel*
crudeltà, *cruelty*
crudo, *raw*
CUCCHIAIO, *spoon*
cucina, *kitchen*
cucire, *to sew, stitch*
cugino, *cousin*
CUOCERE, *to cook, boil*
CUORE (m.), *heart*
cura, *care, cure, parish*
CURIOSO, *curious*

D

DANARO, *money*
danno, *damage*
dannoso, *hurtful*
danzare, *to dance*
DARE, *to give*
DATA, *date*
DAVVERO, *in truth*
DEBITO, *due, debt, debit*
DEBOLE, *feeble, faint*
decreto, *decree*
defunto, *deceased*
degnare, *to condescend*
degno, *worthy*
delicatezza, *delicacy*
DELICATO, *delicate*
delitto, *crime*
delizia, *delight*
delizioso, *delicious*
demenza, *madness*
DENTE (m.), *tooth*
DESTINO, *destiny*
DESTRA, *right (hand)*
A DESTRA, *to the right*
destro, *dextrous*
dialetto, *dialect*
diario, *diary*
diAvolo, *devil*
difEndere, *to defend*
difesa, *defence*
difetto, *defect*
DIFFERENTE, *different*
differenza, *difference*
DIFFICILE, *difficult*
DIFFICOLTÀ, *difficulty*
dignità, *dignity*
dimandare, *to ask, to request*
DIMENTICARE, *to forget*
dimentichEvole, *forgetful*
dimorare, *to dwell*
dimonstrare, *to show*
DIO (IDDIO), *God*
DIRE, *to say, to tell*
dirett-o(-ore), *direct (-or)*
direzione, *direction*
DIRITTO, *straight, upright* (also *law, right*)
disagio, *hardship*
disarmare, *to disarm*
disastro, *disaster*
disavvantaggio, *disadvantage*
DISAVVENTURA, *mishap*
discolpa, *excuse*
discortese, *uncivil*
discosto, *remote*
discreto, *discreet*
disfatta, *defeat*
DISGRAZIA, *disaster, misfortune*
disgusto, *disgust*
disleale, *disloyal*
DISOCCUPATO, *unoccupied*
DISONESTO, *dishonest*
DISORDINE, *disorder, confusion*
dispaccio, *dispatch*
DISPARIRE, *disappear*
DISPIACERE, *to displease, displeasure*
dispiacEvole, *unpleasant*
dispregiare, *to despise*
dispregio, *contempt*
DISPUTA, *dispute, argument*
dissImile, *unlike*
dissoluto, *dissolute*
DISTANTE, *distant*
DISTINTO, *clear*
distretto, *needy*

[1] **Capo** makes many compounds and phrases. **Capo d'anno**, *New Year's Day*; **capostazione** *stationmaster*, etc. Look up a good dictionary.
[2] **Cavaliere** is also a title

distribuire, *to distribute*
disvantaggio, *disadvantage*
dito, *finger, inch*
dittatore, *dictator*
diverso, *diverse, different, various*
divertirsi, *to amuse oneself*
dividere, *to divide*
divisione, *division*
diviso, *divided*
divoto, *devout*
dolce, *sweet*
dolcezza, *sweetness*
dolEre, *to suffer, ache*
dolore (m.), *pain, grief*
domanda, *question, request*
domandare, *to ask*
domani (also **dimani**), *to-morrow*
domattina, *tomorrow morning*
donna, *woman*[1]
dono, *gift*
doppiare, *to double*
doppio, *double*
dormire, *to sleep*
dosso, *back*
dotto, *learned*
dottore, *doctor*
dovEre, *to owe, to be obliged to*
dubbio, *doubt*
dubitare, *to doubt*
duce, *leader*
duomo, *cathedral*
duro, *hard*

E

Ebbro, *drunken*
ebrietà, *intoxication*
eccellente, *excellent*
eccessivo, *excessive*
eccetto, *except*
eccezione, *exception*
ecclesiAstico, *priest, churchman*
ECCO, *behold! here is*
edifIcio, *edifice*
editore, *editor, publisher*
edizione, *edition*
EDUCARE, *to educate*
effetto, *effect*
efficace, *efficacious*
eguale, *equal*
egualità, *equality*
ELEGANTE, *elegant*
ELEMENTO, *element*
eletto, *chosen*
ELETTRICO, *electric*
elUdere, *to elude*
emigrare, *to emigrate*
EMPIÈRE, *to fill*
energia, *energy*
enErgico, *energetic*
enorme, *enormous*
ENTRARE, *to enter*
ENTRATA, *entrance*
ERA, *era*
ERBA, *herb, grass*
erede, *heir*
eretto, *erect*
erOe, *hero*
erOico, *heroic*
errare, *to wander*
errore (m.), *error*
erto, *steep*
ESAMINARE, *to examine*
esatto, *exact*

[1] **Donna** is also a title (*Lady*——).

ESEMPIO, *example*
ESERCITO, *army*
ESERCIZIO, *exercise*
esistenza, *existence*
Esito, *issue, exit*
ESPERIENZA, *experience*
esperimento, *experiment*
ESPERTO, *expert*
esplicare, *to explain*
esposizione, *exposition, exhibition*
espressione, *expression*
ESPRESSO, *express*
ESSERE, *to be*
ESTERIORE (m.), *exterior*
ESTERO, *foreign*[2]
ESTESO, *extent*
ESTREMO, *extreme*
età, *age, century*
eterno, *eternal*
etichetta, *label, ticket*
EVIDENTE, *evident*
evidenza, *evidence*
EVITARE, *to avoid*

F

FABBRICA, *manufactory, building*
fabbro, *smith, maker*
facchino, *porter*
faccia, *face*
FACILE, *easy*
facoltà, *faculty, power*
FALLIRE, *to fail*
fallo, *failure*
FALSO, *false (-ly)*
FAMA, *fame*
FAME (f.), *hunger*
FAMIGLIA, *family*
FAMOSO, *famous*
FANCIULLO, *young boy*
fanteria, *infantry*
fardello, *bundle*
FARE, *to do, to make*
farina, *flour*
farmacista, *apothecary*
FASCIO,[3] *bundle, bunch*
FATALE, *fatal*
faticare, *to fatigue*
fato, *fate*
fatto, *made* (also n., *fact*)
FAVORE (m.), *favour*
favorire, *to be so kind as*
febbre (f.), *fever*
FEDE (f.), *faith*
fedEle, *faithful*
fedeltà, *fidelity*
felicità, *felicity*
felicitare, *to make happy*, (also *to congratulate*)
FEMMININO, *feminine, female*
fErìa, *holiday, feast-day*
fermo, *stopped, fixed, firm*
feroce, *ferocious*
ferraio, *ironmonger*
FERRO, *iron*
ferrovia, *railway*

[2] **all' éstero**, *abroad*

[3] From the word FASCIO meaning a bundle or bunch (from the fasces or emblem of the old Roman lictors) come many words dealing with the Italian Fascist movement, dating from the foundation in March 1919 by Benito Mussolini (Il Duce The Leader) of the first *Fascio di Combattimento* at Milan. The word Fascio was used figuratively to denote the close union of adherents of the movement. There was the **Partito Nazionale Fascista**, *the National Fascist Party*, of which the members were **Fascisti**, etc., etc.

fErtile, *fertile*
festa, *holiday, festival*
fiamma, *flame*
fianco, *flank, side*
FIASCO, *bottle, flask*
fidanza, *confidence*
fidanzare, *to warrant, to betroth*
fieno, *hay*
fiero, *fierce, cruel, proud*
fiEvole, *feeble*
FIGLIA, **figliola** } *daughter*
FIGLIO, **figliolo** } *son*
figura, *figure*
fila, *row*
filo, *thread, string, wire*
FINALE, *finale*
fine (f.), *end*
fine (m.), *aim*
finestra, *window*
fIngere, *to feign, dissemble*
FINIRE, *to finish*
fino, *fine, nice, thin*
fioco, *hoarse, dim, weak*
FIORE (m.), *flower*
FIRMA, *signature*
FIRMARE, *to sign*
fisco, *exchequer*
FISSO, *fixed, firm*
fiume (m.), *river*
flotta, *fleet.*
FLUIDO, *fluid.*
foglia, *leaf*
foglio, *sheet of paper*
folto, *thick, dense*
fondamento, *foundation*
fondare, *to found*
fondo, *deep*, also *bottom* (n.)
fontana, *fountain*
fOrbici (plur.), *scissors*
FORCHETTA, *table-fork*
foresta, *forest*
forestiere, *stranger*
FORMA, *form*
formaggio, *cheese*
formare, *to form*
formica, *ant*
formosa, *beautiful*
formosità, *beauty*
fornaio, *baker*
forno, *oven*
FORTE, *strong, brave*
FORTUNA, *fortune, good luck*
FORZA, *force*
FORZARE, *to force*
fosco, *dark*
fossa, *ditch, grave*
fotografia, *photograph*
fotOgrafo, *photographer*
fracassare, *to smash*
fracasso, *noise, hubbub*
FRAGILE, *frail*
fragranza, *fragrance*
FRANCO, *free, franc*
francobollo, *postage stamp*

frAngere, *to break*
FRASE (f.), *phrase, sentence*
FRATELLO, *brother*
fraudare,[4] *to defraud*
FREDDO, *cold*
freno, *bit, bridle*
fresco, *fresh, cool*
fretta, *haste*
frIgido, *frigid*
frittata, *omelet*
fritto, *fried*
FRONTE (f.), *front*
frutta, *fruit*
fuga, *flight*
fugg're, *to flee from*
fumare, *to smoke*
FUMO, *smoke*
FUOCO (**foco**), *fire*
FUORI, *except*, also *outside* (adv.)
furia, *fury*
furto, *theft*
FUTURO, *future*

G

gaio, *gay*
gallo, *cock*
gana, *eagerness*
gancio, *hook*
garantire, *to warrant*
GAS, *gas*
gatto, *cat*
gazzetta, *newspaper*
GELARE, *to freeze*
gelata, *frost, ice*
gelato, *frozen, cold; ice-cream*
gElido, *frozen, very cold*
gelo, *ice, frost*
generale, *general*
GENERE (m.), *kind, sort, species*
generoso, *generous*
gEnio, *genius*
GENTE (f.), *people*
gentilezza, *gentility, kindness*
gesto, *gesture*
gettare, *to throw, to cast*
GIACERE, *to lie down*
GIALLO, *yellow*
giardino, *garden*
ginocchio, *knee*
GIOCARE, *to play* (games), *frolic, gamble*
giocondo, *joyful*
giocoso, *jocose*
gioia, *jewel;* also *joy*
giornale (m.), *journal, newspaper*
giornata, *day, journey, day's work*
GIORNO, *day*
GIOVANE, *young*
gioventù (f.), *youth, young man*
GIOVINEZZA, *youth, youthfulness*
girare, *to turn*
giro, *turn*
GIUDICARE, *to judge*
giUdice, *judge*
GIUDIZIO, *judgement, prudence; court of justice*
GIUNGERE, *to arrive at*
giunta, *arrival, meeting*

[4] Also written **frodare**.

giuOco, *game, play*
GIURARE, *to swear*
GIUSTIZIA *justice*
GIUSTO, *just, right, upright*
GLOBO, *globe*
GLORIA, *glory*
glorioso, *glorious*
GOCCIA, *drop*
godEre, *to enjoy, rejoice*
gola, *throat, glutton*
GOMMA, *gum, rubber*
gota, *cheek*
governare, *to steer, govern*
GOVERNO, *government*
grAcile, *slender, delicate*
gradEvole, *agreeable, pleasing*
gradimento, *approval, acceptance, pleasure*
GRADO, *degree, dignity*
GRADUALE, *gradual*
grammAtica, *grammar*
GRANDE, *great*
grandezza, *greatness*
grano, *grain, corn, wheat*
grasso, *fat*
grato, *grateful*
grave, *grave, heavy*
grazia, *grace*
GRAZIE ! *thanks*
grazioso, *graceful, agreeable*
grido, *cry*
grosso, *big, coarse*
GRUPPO, *group*
GUADAGNARE, *to gain, to earn*
guadagno, *gain*
guanto, *glove*
guardare, *to look*
GUARDIA, *guard, sentry*
guarire, *to cure*
guarnire, *to furnish*
guastare, *to spoil, to waste*
guasto, *ruin, waste*
GUERRA, *war*
GUIDA, *guide*
guidare, *to guide*
GUSTARE, *to taste, to please*
GUSTO, *taste*
gustoso, *pleasing*

I

IDEA, *idea*
idiota, *idiot*
ignorante, *ignorant*
IGNORARE, *not to know*
ignoto, *unknown*
IGNUDO (nudo), *naked, nude*
ILLEGALE, *illegal*
illustrare, *to illustrate*
imbarcarsi (per), *to embark (for)*
imbrogliare, *to perplex*
imbroglio, *perplexity, trouble, tangle*
IMITARE, *to imitate*
imitazione, *imitation*
IMMAGINARE, *to imagine*
IMMAGINAZIONE, *imagination*
IMMATURO, *immature*
IMMEDIATO, *immediate*
IMMENSO, *immense*
immondo, *filthy*
IMMORTALE, *immortal*
IMPARARE, *to teach, to learn*
impedire, *to hinder*
impegnare, *to pledge*
imperatore,[1] *emperor*
IMPERFETTO, *imperfect*
IMPERITO, *unskilled*
IMPERO, *empire*
impiegare, *to employ*
IMPIEGATO, *employee, clerk*
implorare, *to implore*
IMPORTANTE, *important*
importare, *to import; to matter*
IMPOSSIBILE, *impossible*
imposta, *tax*
impotenza, *weakness*
IMPRESA, *enterprise*
impressione (f.), *impression*
improbo, *wicked, impossible*
improvviso, *unexpected*
INABILE, *incapable*
inabilità, *inability*
inabitAbile, *uninhabitable*
incamminare, *to begin, to set on foot*
INCAPACE, *incapable*
INCERTO, *uncertain*
inchiEdere, *to inquire*
inchiesta, *inquest*
inchinarsi, *to bend, incline*
inchiostro, *ink*
INCHIUDERE, *to include*
inclinare, *to incline*
INCÓGNITO, *unknown*
incOlto, *uncultivated*
incominciare, *to start, to begin*
incomodare, *to trouble*
INCÓMODO, *inconvenient*
incompetente, *incompetent*
INCONTRARE, *to meet*
incontrarsi, *to fall in with*
incorporare, *to incorporate*
incuria, *negligence*
indegno, *unworthy*
INDICARE, *to indicate*
INDICE (m.), *index*
indimenticAbile, *unforgettable*
indiretto, *indirect*
indirizzare, *to show, to direct*
INDIRIZZO, *direction*
indisposto, *indisposed*
INDIVIDUO, *individual, fellow*
indiviso, *undivided*
indizio, *sign, indication*
INDOLE (f.), *natural disposition, character*
INEGUALE, *unequal*
INFAME, *infamous*
INFEDELE, *unfaithful*
INFELICE, *unhappy*
INFERIORE, *inferior*
infermarsi, *to fall sick*
infermo, *infirm* (also n., *patient, sick person*)
inferno, *hell*
infimo, *lowest, vilest*
INFINE, *at last*
infinità, *infinity*
infinito, *endless*

[1] Fem. **Imperatrice**, *Empress*

influenza, *influence, authority, influenza*
informare, *to inform*
INFORMAZIONE, *information*
informe, *shapeless*
INGANNARE, *to deceive*
INGANNARSI, *to be mistaken*
ingannEvole, *deceitful*
inganno, *deceit, mistake*
ingegnEre, *engineer*
INGEGNO, *natural talent, genius*
ingiuria, *injury, wrong*
INGIUSTO, *unjust*
ingordo, *greedy*
ingozzare, *to swallow*
ingrandire, *to increase*
INGRATO, *ungrateful*
ingresso, *entrance, arrival*
ingrosso, *wholesale*
INIMICO, *enemy*
INIZIO, *beginning*
innamorarsi, *to fall in love*
innato, *inborn*
inno, *hymn*
inquieto, *restless*
insania, *madness*
INSEGNA, *flag, sign*
INSENSATO, *foolish*
insensibile, *insensible*
insetto, *insect*
INSIEME, *together*
insigne, *notable*
INSISTERE, *to insist*
insOlito, *unusual, rare*
insulto, *insult*
intatto, *untouched*
integrale, *integral*
integro, *upright*
intelletto, *intellect*
INTELLIGENTE, *intelligent*
INTENDERE, *to understand, hear*
INTENSO, *intense*
intentare, *to attempt*
intento, *attentive*
INTERESSANTE, *interesting*
INTERESSE (m.), *interest*
INTERIORE (m.), *interior*
interno (adj.), *interior*

L

labbro (plur. -a), *lip*[1]
laborioso, *laborious*
ladro, *thief, robber*
lago, *lake*
lAgrima, *tear*
lagrimare, *to weep*
lAmina, *blade*
lAmpada, *lamp*
lana, *wool*
LAPIS (m.), *pencil, crayon*
larghezza, *largeness, width*
LARGO, *broad, wide, bountiful*
LASCIARE, *to leave, abandon*
LASSO, *tired*
LATO, *side*
LATTE (m.), *milk*
lattuga, *lettuce*

[1] **Labbro** is masculine in the singular and feminine in the plural.

LAVARE, *to wash*
LAVORARE, *to work, labour*
LAVORO, *work*
leale, *loyal*
lega, *league*
legale, *legal*
LEGGE (f.), *law*
LEGGÈRE, *to read*
LEGGERO, *light*
legno, *wood*
LEGUME (m.), *vegetable*
LENTO, *slow*
leone, *lion*. (Also **lione**)
LETTERA, *letter*
LETTO, *bed*
LETTORE, *reader*
levare, *to raise*
LEVARSI, *to get up*
LEZIONE, *lesson*
LIBBRA, *pound* (weight)
liberale, *liberal*
liberare, *to free*
LIBERO, *free, frank*
libertà, *liberty*
libraio, *bookseller*
libreria, *bookseller's shop*
LIBRO, *book*
lido, *shore*
lieto, *joyous*
lieve, *light, easy*
LIMITE (m.), *limit*
limone (m.), *lemon*
limOsina, *alms*
lindo, *neat*
LINEA, *line*
LINGUA, *tongue, language*
LIQUIDO, *liquid, fluid*
lira sterlina, *pound sterling*
lista, *list*
litro, *litre*
lodare, *to praise*
lode (f.), *praise*
LOGICO, *logical*
LONTANO, *distant*
lottare, *to wrestle*
LUCE (f.), *light*
lucro, *gain*
lUgubre, *mournful, lugubrious*
LUNA, *moon*
lunghezza, *length*
LUNGO, *long*
luogo, *place*
lupo, *wolf*
lusingare, *to flatter*
lusso, *luxury*
lustrare, *to shine* (trans.), *polish*
lutto, *mourning*

M

macchia, *stain*
MACCHINA, *machine*
madonna, *lady* (*Virgin Mary*)
MADRE, *mother*
maestà, *majesty*
maestro, *master*
MAGGIORE, *bigger, greater*
magro, *meagre, thin*
MALATTIA, *sickness*
malcreato, *impolite, ill-bred*
MALE (m.), *evil, ill*
malgrado, *in spite of*
malizia, *malice*
MALSANO, *unhealthy*
mancare, *to want, to lack*

mancia, *tip, gratuity*
manco, *defective, wanting* (adj.); *want, defect* (n.)
MANDARE, *to send*
MANGIARE, *to eat*
MANIERA, *manner*
MANIFATTURA, *manufacture*
manifesto, *manifest*
MANO, *hand*
mantenere, *to maintain*
maraviglia, *wonder*
maravigliarsi, *to wonder*
marcare, *to mark*
MARCO, *mark*
MARE (m.), *sea*
marea, *tide*
marina, *sea-coast*
marinaio, *mariner*
marino, *maritime*
MARITO, *husband*
marmo, *marble*
martello, *hammer*
maschile, *manly*
maschio, *male, manly*
matemAtica, *mathematics*
matEria, *matter*
matrimOnio, *matrimony*
MATTINA, *morning*
matto, *mad*
MEDESIMO, *same, self* (Fr. même)
MEDICINA, *medicine*
MEDICO, *physician*
MEDIO, *middle*
MEGLIO, *better*
mela, *apple*
MEMORIA, *memory*
mendicare, *to beg*
MENTE (f.), *mind*
MENZOGNA, *falsehood*
MERCANTE, *merchant*
MERCATO, *market-place*
MERITO, *merit, reward*
meschino, *miserable, mean*
MESE (m.), *month*
messaggero, *messenger*
METODO, *method*
METRO, *metre*
METTERE, *to put, to set*
MEZZO, *middle, half*
miele (m.), *honey*
MILITARE, *military*
minestra (-one), *broth, soup*
ministero, *administration*
ministro, *minister*
MINUTO, *small*, also *minute* (n.)
mira, *aim, sight*
miserAbile, *miserable*
MISERIA, *misery*
MISERICORDIA, *compassion, mercy*
misterioso, *mysterious*
MISTURA, *mixture*
MÒBILE, *movable, fickle*
MODA, *mode, fashion*
MODELLO, *model*
MODERATO, *moderate*
MODERNO, *modern*
MODESTO, *modest*
MODO, *manner, mood*
MOGLIE, *wife, woman*
MOLLE, *soft*
moltiplicare, *to multiply*
moltiplicazione, *multiplication*
MOLTO, *very, many, much*
MOMENTO, *moment*
monarca, *monarch*
MONDO, *world*
MONETA, *coin, money*
MONTAGNA, *mountain*
MONTARE, *to ascend*
MONTE (m.), *mountain*
MONUMENTO, *monument*
moralità, *morality*
morbo, *disease*
MORIRE, *to die*
MORTE (f.), *death*
MORTO, *dead*
mosca, *fly*
mosso (p.p.), *moved*
mostarda, *mustard*
MOSTRA, *sample, show*
MOSTRARE, *to show*
moto, *movement, motion*
movimento, *movement*
multa, *fine, penalty*
municipale, *municipal*
MUOVERE (mOvere), *to move, incite, to go*
muraglia, *wall*
museo, *museum*
MUSICA, *music*
musicista, *musician, musical*
MUTO, *dumb*

N

NASCERE, *to be born*
NASO, *nose*
NATURA, *nature*
NATURALE, *natural*
naufrAgio, *shipwreck*
nave (f.), *ship* (large)
NAZIONE, *nation*
NECESSITÀ, *necessity*
NEGARE, *to deny*
NEGLIGERE, *to neglect*
NEGOZIARE, *to negotiate*
NEMICO, *enemy*
NERO, *black*
netto, *clean*
NEVE (f.), *snow*
nevicare, *to snow*
nido, *nest*
NIENTE, *nothing*
nipOte, *nephew, niece*
NO, *no, not*
nObile, *nobleman, noble*
noce (f.) *nut, walnut*
NOME (m.), *name*
nominare, *to name*
NON, *not, no*
NOTA, *note, mark*
NOTIZIA, *notice*
NOTTE (f.), *night*
novità, *novelty*
NUDO, *naked*
NUMERO, *number*
NUOVO, *new*

O

obbediente, *obedient*
occhiali, *spectacles*
occhio, *eye*
OCEANO, *ocean*
ODIO, *hatred*
offEndere, *to offend*
OFFERTA, *offer*
officina, *work-shop*
OFFRIRE, *to offer*
OGGETTO, *object*
OGGI, *today*
OGNI, *every, all*
OLIO, *oil*
oliva (also **uliva**), *olive*
onda, *wave*
onestà, *honesty*
ONESTO, *honest*
onorario, *fee, stipend, salary*
onore (m.), *honour*
onta, *shame*
ontoso, *shameful*
ÒPERA, *work, opera*
opposto, *opposite*
OPPRIMERE, *to oppress*
ORA, *hour*
orare, *to pray*
orario, *timetable*
ordinario, *ordinary*
ORECCHIO, *ear*
orgOglio, *pride*
ORIGINE (f.), *origin*
orizzonte (m.), *horizon*
ORO, *gold*
orologio, *watch, clock*
orribile, *horrible*
osare, *to dare*
oscurità, *obscurity*
oscuro, *obscure*
ospedale (m.), *hospital*
OSSERVARE, *to observe*
osservatore, *observer*
osso, *bone* (pl. le ossa)
oste, *host, innkeeper*
osteria, *inn, hostelry*
ostile, *hostile*
ostinato, *obstinate*
ÒTTIMO, *best*
ozio, *leisure, idleness*

P

pacchetto, *packet*
PACE (f.), *peace*
PADRE, *father*
padrone, *master*
PAESE (m.), *country*
paga, *pay, salary*
PAGARE, *to pay*
PAGINA, *page* (of book)
paglia, *straw*
pagamento, *payment*
paio, *pair* (pl. **le paia**)
palazzo, *palace*
PANE (m.), *bread*
PANNO, *stuff* (cloth)
papa, *pope*
papale, *papal*
paradiso, *paradise*
parallelo, *parallel*
parente, *kinsman, parent*
parentela, *relationship, kinship*
PARERE, *to appear*
pari, *alike, equal*
parlamento, *parliament*
PARLARE, *to speak*
PAROLA, *word*
parrOcchia, *parish*
PARTE (f.), *part, place*
partenza, *departure*
partire, *to depart*
PARTITA, *departure, game*
Pasqua, *Easter*
passAggio, *passage*
passaporto, *passport*
PASSARE, *to pass*
passato, *past* (n and adj.)
passeggiere, *passenger*
PASSO, *step, pace*
pasto, *food, repast*
patata, *potato*
PAURA, *fear*
pausa, *pause*
pazzo, *mad*
peccare, *to sin*
peccato, *sin*
pelle (f.), *skin*
pelo, *hair*
pena, *pain, punishment*
PENNA, *feather, pen*
PENSARE, *to think*
pensiere (m.), *thought*
pentirsi, *to repent*
PERDERE, *to lose*
PERDONARE, *to pardon*
perdono, *pardon, forgiveness*
PERDUTO, *lost*
PERFETTO, *perfect*
perfezione, *perfection*
pericolo, *danger*
pericoloso, *dangerous*
perire, *to perish*
perito, *expert*
perizia, *skill*
permanente, *permanent*
PERMESSO, *permission*
permEttere, *to permit*
PERSONA, *person*
persuadEre, *to persuade*
PESANTE, *heavy*
pesare, *to weigh*
pesce (m.), *fish*
PESO, *weight*
PEZZO, *bit, piece*
PIACERE, *to please*
piacEvole, *pleasing*
piAngere, *to weep*
PIANO, *plain, level, gently, soft*
PIANTA, *plant*
piatto, *dish*
PIAZZA, *place, square*
piccolo, *small*
PIEDE (m.), *foot*
piegare, *to fold*
PIENO, *full*
pietà, *piety, pity*
PIETRA, *stone*
pigro, *lazy, idle*
pilota, *pilot*
pingere, *to paint* (also *to push*)
pio, *pious*
PIOGGIA, *rain*
PIOVERE, *to rain*
pipa, *tobacco-pipe*
pittore, *painter*
pittura, *painting*
piuttosto, *rather, somewhat*
pochezza, *smallness*
POCO, *little, few*
PODERE, *power*
podestà, *magistrate*
poema (m.), *poem*
poesia, *poetry*
poeta, *poet*
poggio, *hill, hillock*
POLITICO, *political*
polito, *polished*
pOllice (m.), *thumb*
POLLO, *chicken*
polmone (m.), *lungs*
PÓLVERE (f.), *dust, powder*
polveroso, *dusty*
pomo, *apple*
ponte (m.), *bridge*
popolare, *popular*
PÓPOLO, *people*
popoloso, *populous*
porco, *pig*

porre, *to put*
PORTA, *door, gate*
PORTARE, *to carry, to wear*
porto, *port*
POSIZIONE, *position*
POSSEDERE, *to possess*
POSSIBILE, *possible*
possibilità, *possibility*
posta, *post*
POTERE, *to be able*
POVERO, *poor*
povertà, *poverty*
pranzare, *to dine*
PRANZO, *dinner*
PRATICA, *practice*
praticare, *to practise*
precauzione, *precaution*
preciso, *precise*
preferenza, *preference*
prEmere, *to press*
PRENDERE, *to take, to seize*
PREPARARE, *to prepare*
presa, *capture, catch*
PRESENTE (n. and adj.), *present* (time)
preservare, *to preserve*
PRESSO, *near, at*[1]
PRESTARE, *to lend*
PRESTO, *quick*
pretEndere, *to pretend*
pretesto, *pretext*
prezioso, *precious*
PREZZO, *price*
prigione (f.), *prison*
PRIMA, *before, first*
primo, *first*
PRINCIPALE, *principal, chief*
principe, *prince*
principiare, *to begin*
principio, *beginning*
PROBABILE, *probable*
probo, *upright*
professore, *professor*
profondo, *depth, deep*
progetto, *project*
programma (m.), *programme*
PROGRESSO, *progress*
PROMESSA, *promise*
PRONTO, *ready, at hand*
PRONUNCIARE, *to pronounce*
propOsito, *intention*
proprietà, *property*
PROPRIO, *own, proper, peculiar to*
prosa, *prose*
prosciutto, *ham*
PROVA, *proof*
PROVARE, *to try, to prove*
PROVINCIA, *province*
prudente, *prudent*
pulire, *to clean, to polish*
PULITO, *clean, polished*
PUNIRE, *to punish*
PUNTO, *point*
PURE, *yet, even, still*
PURO, *pure*

Q

qua } *here, hither*
QUI }
quadro, *square, picture painting*
QUALITÀ, *quality*
QUANTITÀ, *quantity*
QUESTIONE, *question*
quieto, *quiet, still*
quotidiano, *daily*

R

rAbbia, *fury*
rabbioso, *enraged, furious*
RACCOLTA, *collection, crop, harvest*
raccomodare, *to mend*
raccontare, *to relate*
racconto, *account, story*
radice (f.), *root*
RAGAZZO, -A, *boy, girl*
RAGIONE (f.), *reason*
ragno, *spider*
ramo, *branch*
rango, *rank, degree*
RAPIDO, *rapid, quick*
rapporto, *report*
rarità, *rarity, scarcity*
RARO, *rare, thin, scarce*
rata, *rate, instalment*
razza, *race*
RE, *king*
reale, *royal, real, true*
recente, *recent*
reclamare, *to protest*
refrigerare, *to cool*
regalare, *to make a present of*
regalo, *gift, present*
rEggere, *to rule*
regina, *queen*
REGIONE (f.), *region*
registrare, *to register*
registro, *register*
REGNO, *kingdom, reign*
regolare, *to regulate*
RELIGIONE, *religion*
reo, *guilty*
repente, *sudden(ly)*[1]
REPUBBLICA, *republic*
residuo, *remainder*
respirare, *to breathe*
respiro, *breath*
RESTO, *remainder*
rete (f.), *net, network*
retro, *backward*
retto, *right, upright*
ricchezza, *riches*
RICCO, *rich*
ricEvere, *to receive*
ricevuta, *receipt*
RICORDARE, *to remember, to mention*
ricordo, *remembrance*
ricusare, *to refuse*
RIDERE, *to laugh*
rifiuto, *refusal*
RIFUGIO, *refuge*
RIGIDO, *rigid*
rigore (m.), *rigour*
riguardo, *look, regard*
rilassato, *slack, relaxed*
rima, *rhyme*
rimanEre, *to remain*
rimedio, *remedy*
rimorso, *remorse*
ringraziare, *to thank*
rinnovare, *to renovate*
rinomanza, *renown*
ripido, *steep*
ripieno, *full, stuffed*
riputazione, *reputation*
RISA (pl.), *laughter*
risanare, *to cure*
rischio, *risk, danger*
riso, *rice*
risOlvere, *to dissolve, to resolve*
rispetto, *respect, regard*
RISPÓNDERE, *to answer*
RISPOSTA, *answer*
ristorante (m.), *restaurant*
ristretto, *restricted*
ritornare, *to return*
ritto, *right, straight, just*
riuscire, *to succeed*
RIUSCITA, *success*
riva, *shore, bank*
riverso, *reverse, overflow*
riviera, *sea-shore, river*
rivista, *review*
ROBA, *goods, gown*
rOccia, *rock, precipice*
RÓMPERE, *to break*
rosa, *rose*
rosso, *red*
rostro, *beak*
ROTONDO, *round*
ROTTO, *broken, smashed*
rovinare, *to ruin*

S

sala, *hall*
SALE (m.), *salt*
salsa, *sauce*
SALUTE (f.), *health safety*
SALVARE, *to save*
salvo, *safe, except*
sanare, *to heal*
sAngue (m.), *blood*
sanità, *health*
SANO, *sound, healthy*
santo, *saint, holy*
SAPERE, *to know, understand*
sapienza, *wisdom*
SAPONE (m.), *soap*
sapore (m.), *savour, taste*
sarto, *tailor*
sAvio, *wiseman* (*wise*, adj.)
sbadato, *negligent*
SBAGLIAR(SI), *to be mistaken*
SBAGLIO, *mistake, error*
sballare, *to unpack*
sbarcare, *to disembark*
scafo,[1] *hull of a ship*
scala, *stairs*
scappare, *to escape*
scappata, *escape, flight*
scarlatto, *scarlet*
scarpa, *shoe*
scarso, *scarce, niggardly*
SCATOLA, *box, case*
scEgliere, *to choose, select*
SCELTO, *chosen*
scemo, *deficient, silly*
scena, *scene, stage*
SCENDERE, *to descend*
scErnere, *to discern*
scesa, *descent, velocity*
schema (m.), *scheme*
schermo, *defence* (also *screen*)
scherzare, *to jest, joke*
scherzo, *jest*
schiavitù, *slavery*
schiavo, *slave*
sciente, *learned, knowing aware*
scientifico, *scientific*
SCIENZA, *science*
scintilla, *spark, sparkle*
scioperato, *idle*
scolaro, *scholar*
SCÓMODO, *inconvenient*
SCOPERTA, *discovery*
scorso, *oversight*
scrittoio, *writing-desk*
scrittore, *writer*
scrittura, *writing, scripture*
SCRIVERE, *to write*
SCUOLA, *school*
scuro, *dark, obscure*
scusare, *to excuse*
SECCO, *dry*
secolare, *secular*
SECOLO, *century, age*
SECONDO, *second*
sedEre, *to sit down*
sEdia, *chair, seat*
sedizione, *sedition*
SEGNALE (m.), *signal*
segnare, *to mark*
SEGNO, *sign*
segretario, *secretary*
SEGRETO, *secret*
seguente, *following*
SEGUIRE, *to follow*
selva, *forest*
selvaggio, *wild*
sembianza, *face, appearance*
sembrare, *to seem*
seme (m.), *seed*
sEmplice, *simple, pure*
senso, *sense, meaning*
sentimento, *feeling*
SENTIRE, *to feel*
SEPARARE, *to separate*
SERA,[1] *evening*
sErie (f.), *series*
serio, *serious, grave*
serrare, *to shut, lock*
servire, *to serve*
seta, *silk*
SETE (f.), *thirst*
SETTIMANA, *week*
severo, *severe*
SEZIONE, *section*
sfera, *sphere*
sfortunato, *unhappy*
sforzare, *to constrain*
sforzo, *effort*
sgarbato, *impolite*
sghembo, *crooked, oblique*
sgradire, *to displease*
sgraziato, *unfortunate*
sguardo, *look, glance*
sicurezza, *security*
SICURO, *safe, sure*
SIGNORA, *lady*
SIGNORE, *gentleman*
SIGNORIA, *lordship* (*dominion*)
SIGNORINA, *young lady, miss*
silenzio, *silence*
simpAtico, *attractive charming*
sincero, *sincere*
sinistra, *left* (*-hand*)
SINISTRO, *left* (also, *accident*)
SISTEMA (m.), *system*
sito, *site*
smarrire, *lose, wander*
smontare, *to descend*
snello, *nimble*
soave, *sweet*

[1] **Presso** is also used for c/o in addressing letters

[1] More common in the phrase **di repente**, *suddenly*

[1] **Piroscafo** *liner*, **motoscafo** *motor-ship*, etc.

[1] **Buona sera!** *Good evening!*

sobrio, *sober*
soccorso, *succour*
SOCIETÀ, *society*
SODDISFARE, *to satisfy*
soffrire, *to suffer*
SOGNO, *dream*
SOLDATO, *soldier*
sole (m.), *sun*
solenne, *solemn*
SOLERE, *to be accustomed, wont*
SÓLIDO, *solid*
SÓLITO, *accustomed*
SOLO, *only, alone*
SOLTANTO, *solely*
soma, *burden, load*
SOMMA, *sum*
SONARE, *see* SUONARE
SONNO, *sleep*
sordo, *deaf*
SORELLA, *sister*
sorpresa, *surprise*
SORTE (f.), *fate, state, condition*
sospettare, *to suspect*
sostanza, *substance*
sostenEre, *to support*
sottomEttere, *to submit*
spaventare, *to frighten*
spavento, *fright*
SPAZIO, *space*
specchio, *looking-glass*
SPECIALE, *special*
spEcie (f.), *species*
spedale (m.), *hospital*
spedire, *to dispatch*
spedito, *prompt*
spEndere, *to spend*
SPERANZA, *hope*
SPERARE, *to hope*
sperienza, *experience*
spesso, *thick, dense*
spettAcolo, *spectacle, show, display*
spiacere (intr.), *to be displeased, sorry*
SPIRITO, *spirit, mind*
splEndere, *to shine*
SPLENDIDO, *splendid*
sporcare, *to soil*
SPORCO, *filthy, dirty*
sposare, *to marry*
stAbile, *stable*
stabilire, *to establish*
stabilità, *stability*
STAGIONE (f.), *season, stage*
stamattina, *this morning*
STAMPA, *press, printing*
STAMPARE, *to stamp, to print*
stamperia, *printing-office*
stancare, *to tire*
STANCARSI, *to get tired*
STANCO, *tired*
STANZA, *room, apartment, dwelling*
STARE, *to stand, to stop, to be, to dwell*
STASERA, *this evening*
STATO, *state, rank*
STAZIONE, *station*
stella, *star*
STESSO, *same*
stima, *esteem*
stoffa, *stuff*
stOmaco, *stomach*
STÓRIA, *history, story*
STRADA, *road, route, way, street*
STRANIERO, *foreigner*
strano, *strange, shocking*
straordinario, *extraordinary*
stretto, *strict, narrow*
studente, *student*
STUDIARE, *to study*
studio, *study*
stupendo, *surprising*
STUPIDO, *stupid*
sturbare, *to disturb*
SUBITO, *sudden, immediately*
succEdere, *to succeed, to happen*
successo, *success, conclusion*
SUONARE, *to sound, ring* (also, *to play music*)
superbo, *proud*
supErfluo, *superfluous*
SUPERIORE, *superior, better*
suppa, *soup* (or **zuppa**)
suppOrre, *to suppose*
SUPREMO, *supreme*
sussurro, *murmur*
svanire, *to vanish*
svantaggio, *disadvantage*
svegliare, *to awake*
svelto, *nimble, quick*
sventura, *misfortune*
SVENTURATO, *unfortunate*

T

tabacco, *tobacco*
TACERE, *to be silent*
tAcito, *silent*
taciturno, *taciturn*
TAGLIARE, *to cut, shorten*
talento, *inclination, talent*
tapino, *wretched, miserable*
TARDARE, *to delay*
TASCA, *pocket*
tassa, *tax*
TAVOLA, *table*
TAZZA, *cup*
te (m.), *tea*
teatro, *theatre*
tela, *cloth, linen, painting*
TELEFONO, *telephone*
telEgrafo, *telegraph*
TELEGRAMMA (m.), *telegram*
tema, *fear*
TEMERE, *to fear*
tempesta, *tempest*
temperatura, *temperature*
tempio, *temple*
TEMPO, *time, weather*
tEnebre (pl.), *darkness*
TENERE, *to hold*
TENTARE, *to try, attempt*
teoria, *theory*
TERMINARE, *to finish*
TERRA, *earth, land*
terreno, *land, ground*
terribile, *terrible*
terrore (m.), *terror*
tesoro, *treasure*
TESTA, *head*
tetro, *dark, gloomy*
TETTO, *roof*
timido, *timid*
TIMORE (m.), *fear*
tirare, *to draw, shoot*
TOCCARE, *to touch*
tomo, *volume, book*
tonare, *to thunder*
toro, *bull*
tornare, *to return, become again*
torre (f.), *tower*
torrente (m.), *torrent*
tosse (f.), *cough*
tosto, *quick, soon*
traduzione, *translation*
TRAFFICO, *traffic*
tragEdia, *tragedy*
trasmEttere, *to transmit*
transparente, *transparent*
TRASPORTO, *transport*
traversare, *to traverse, go across*
TRENO, *train*
tribunale (m.), *court of law*
tristezza, *sadness*
TRISTO, *sad*
TROVARE, *to find*
truffare, *to cheat*
tuOno, *thunder*

U

UBBIDIRE, *to obey*
ubbriaco, *drunk*
uccello, *bird*
uccidere, *to kill, murder*
udienza, *audience*
udire, *to hear*
ufficiale, *official*
UGUALE, *equal*
ULTIMO, *last*
umano, *human, humane*
UMIDO, *moist*
Umile, *humble*
umiliare, *to humble*
umiltà, *humbleness*
uniforme, *uniform*
UNIRE, *to unite*
università, *university*
UOMO, *man* (pl. **uOmini**)
UOVO, *egg* (pl. **uova**)
urgente, *urgent*
usare, *to use*
USCIRE, *to go out*
USCITA, *issue, door, exit, escape*
uso, *use*
UTILE, *useful*
uva, *grape*

V

vacca, *cow*
VAGONE (m.), *wagon*
VALERE, *to be worth*
vAlido, *valid, legal*
VALIGIA, *portmanteau, valise*
valle (f.), *valley*
valore (m.), *value*
vano, *vain*
vantaggio, *advantage*
vapore (m.), *vapour, steamship*
VARIO, *various*
vaso, *vase, vessel*
vasto, *immense*
VECCHIO, *old*
vece,[1] *instead*
VEDERE, *to see*
vEdovo (-a), *widower, widow*
vela, *sail*
veleno, *poison*
VELOCE, *swift*
vena, *vein*
VENDERE, *to sell*

[1] **In vece di,** *instead of.*

vendetta, *vengeance*
vendicare, *to revenge*
VENIRE, *to come*
VENTO, *wind*
ventura, *fortune*
venturo,[2] *future, coming*
venturoso, *lucky*
verace, *true*
VERBO, *verb, word*
VERDE, *green*
VERGOGNA, *shame*
verificare, *to verify*
VERITÀ, *truth*
VERO, *true*
verso, *verse*
vestimento, *dress*
vestire, *to dress*
vezzoso, *nice, charming, graceful*
VIA, *way, road, street*
VIAGGIARE, *to travel*
VIAGGIO, *journey*
vicino, *neighbour*
vico, *narrow lane, street*
VIETARE, *to prohibit*
VIETATO, *forbidden*
vigilare, *to watch*
vigna, *vineyard*
vigore (m.), *vigour*
villaggio, *village*
viltà, *cowardice*
VINCERE, *to conquer, defeat*
vino, *wine*
violento, *violent*
virtu (f.), *virtue*
virtuoso, *virtuous*
visita, *visit*
VISITARE, *to visit*
VISTA, *sight, view*
vita, *life, waist*
vite, *vine*
vittoria, *victory*
vivace, *sprightly*
VIVERE, *to live*
VIVO, *alive*
vizio, *vice*
VOCE (f.), *voice*
VOGLIA, *will, wish*
volare, *to fly*
VOLENTIERI, *willingly*
VOLERE, *to will, to wish*
volgo, *common people, mass*
volo, *flight*
volontà, *will, wish, will-power*
volontario, *voluntary, volunteer*
volpe (f.), *fox*
VOLTA,[3] *turn, time*
VOLTARE, *to turn*
volume (m.), *volume*
vorace, *voracious*
votare, *to empty, to give one's vote, to vow*
voto, *vow, vote*

Z

zelo, *zeal*
ZERO, *zero*
ZIO, *uncle*
zolfanello, *match*
zolfo, *sulphur*
zoppo, *lame*
ZUCCHERO, *sugar*

[2] For example: **Il mese venturo,** *next month.*

[3] **È la mia volta,** *It is my turn.* **Una volta, due volte,** *once, twice,* etc.

LESSON 11

Use and Scope of Grammar and Vocabulary Illustrated

THE passage which follows is from Machiavelli's classic *The Prince*, and is given to show that the grammar and vocabulary in this Course adequately cover normal Italian. If the student has mastered what has been given, he should have no difficulty in reading a letter, a newspaper, or a book, with occasional reference to a dictionary.

FROM *THE PRINCE* BY *NICCOLO MACHIAVELLI*

CHE MODO I PRINCIPI DEBBANO OSSERVARE LA FEDE[1]

IN WHAT WAY PRINCES MUST KEEP FAITH

Quanto sia laudabile in un principe mantenere la fede, vivere
How laudable it is in a prince to keep (good) faith, to live

con integrità e non con astuzia, ciascuno lo intende. Nondimanco si
with integrity and not by cunning, everyone understands. Yet it is

vede per esperienza ne' nostri tempi, quelli principi aver fatto gran
seen by experience in our times (that) those princes have done great

cose, che della fede hanno tenuto poco conto, e che hanno saputo con
things who for good faith have had little regard, and who have known (how)

l'astuzia aggirare i cervelli degli uomini, ed alla fine hanno superato
by trickery to cheat men's brains, and in the end have overcome

quelli che si sono fondati in su la lealtà.
those who have founded themselves on loyalty.

Dovete adunque sapere come sono due generazioni di combattere:
You must know then that there are two ways of fighting:

l'una con le leggi, l'altra con la forza; quel primo (modo) è proprio
one with (the aid of) laws, the other with force; the first way is (an)

dell'uomo, quel secondo delle bestie; ma perchè il primo spesse volte
attribute of man, the second of beast; but because the first very often

non basta, conviene ricorrere al secondo. Pertanto, ad un principe è
is not adequate, it is expedient to (have) recourse to the second. Therefore for

necessario saper bene usare la bestia e l'uomo . . .
a prince it is necessary to know well (how) to use (the qualities of) the beast and man . . .

Essendo adunque un principe necessitato sapere bene usare la
Being then a prince obliged to know well (how) to act as the

bestia, debbe di quella pigliare la volpe e il lione; perchè il lione
beast, he must (in that sense) equal the fox and the lion, because the lion

non si difende da' lacci, la volpe non si difende da' lupi. Bisogna
does not defend himself from snares, (nor) the fox from wolves. He must

adunque essere volpe a conoscere i lacci, e lione a sbigottire i lupi.
therefore be a fox to know snares, and a lion to frighten wolves.

Coloro che stanno semplicemente in sul lione, non se ne intendono. Non
Those who rely simply on (qualities of) the lion, do not understand this. For

può pertanto un signore prudente, nè debbe, osservare la fede, quando tale
this reason a wise overlord cannot and ought not to keep faith when

osservanzia gli torni contro, e che sono spente le cagioni che la
such observance might turn against his interests, and when the causes are

fecero promettere.
gone which made him pledge it.

E se gli uomini fussero tutti buoni, questo precetto non sarebbe
And if men were all good, this precept would not be

buono; ma perchè sono tristi, e non la osserverebbero a te, tu ancora non
good, but because they are contemptible and will not keep (faith) with you

l'hai da osservare a loro. Nè mai ad un principe mancheranno cagioni
you have not to keep it with them. Nor to a prince will there ever lack

legittime de colorare la inosservanzia. Di questo se ne potrebbe
legitimate reasons to colour the non-observance. Of this it is possible

dare infiniti esempi moderni, e mostrare quanti paci, quante promesse
to give infinite modern examples, and to show how many peaces, how many

sono state fatte irrite e vane per la infedeltà dei principi; e quello
promises have been made null and void by the faithlessness of princes; and

che ha saputo meglio usare la volpe, è meglio capitato. Ma è necessario
that he who has known best to use (the wile of) the fox, has best succeeded

questa natura saperla bene colorire, ed essere gran simulatore e
But it is necessary to know well how to camouflage this character and to be

dissimulatore, e sono tanto semplici gli uomini, e tanto ubbidiscono alle
a great hypocrite and dissembler, and men are so ingenuous, and so greatly

necessità presenti, che colui che inganna troverà sempre chi si lascerà
obey present necessities, that he who deceives will find always one who

[1] The example given here is based on the Italian critical text of Mario Casella. The spelling is, however, modernized. In a few instances Machiavelli's words have become archaic, otherwise the student of this Course should be able to follow the meaning.

ingannare . . .
allows himself to be duped . . .

Ad un principe adunque non è necessario avere in fatto tutte le
For a prince, then, it is not necessary in fact to have all the

soprascritte qualità, ma è ben necessario parer di averle. Anzi ardirò
above-mentioned qualities, but it is very necessary to seem to have them. Indeed

di dire questo, che avendole ed osservandole sempre, sono dannose ; e
I will go (so far as) to say this, that to have them and act on them always

parendo d'averle, sono utili : come parer pietoso, fidele, umano, religioso,
is harmful, while to appear to have them is beneficial also to seem compassionate,

intero, ed essere ; ma stare in modo edificato con l'animo che bisognando
faithful, humane, religious, reliable, and to be so : but to be so (constituted) in mind that, not needing to

non essere, tu possa e sappia mutare il contrario. Ed hassi ad intendere
be (any of these), you can, and know (how) to, change to the opposite. And you must

questo, che un principe, e massime un principe nuovo, non può osservare tutte
grasp this, that a prince, and above all a new prince, cannot observe all

quelle cose per le quali gli uomini sono tenuti buoni, essendo spesso
those things by which men are esteemed good, being often

necessitato per mantenere lo stato operare contro alla fede, contro alla
driven in order to maintain the state to act contrary to good faith, against

carità, contro alla umanità, contro alla religione. E però bisogna che
charity, against humanity, against religion. And therefore it behoves him

egli abbia un animo disposto a volgersi secondo che i venti e le
that he have } to have a mind disposed to turn according as the winds and the

variazioni della fortuna gli comandano ; e come di sopra dissi, non partirsi
fluctuations of fortune command it , and as I have said above, not to go away

dal bene potendo, ma sapere entrare nel mal necessitato.
from what is good if possible, but to know how to enter into unavoidable evil.

Statistical Note

Total essential words in Vocabulary	1,650
Structural and other words	350
Total (approximately)	2,000

Of these about 800 general and 350 structural words are given in large type : a total of 1,150. The large type words may be considered as a first approximation to a " Basic Vocabulary " of the Italian language.

Hints for Further Study and Reading

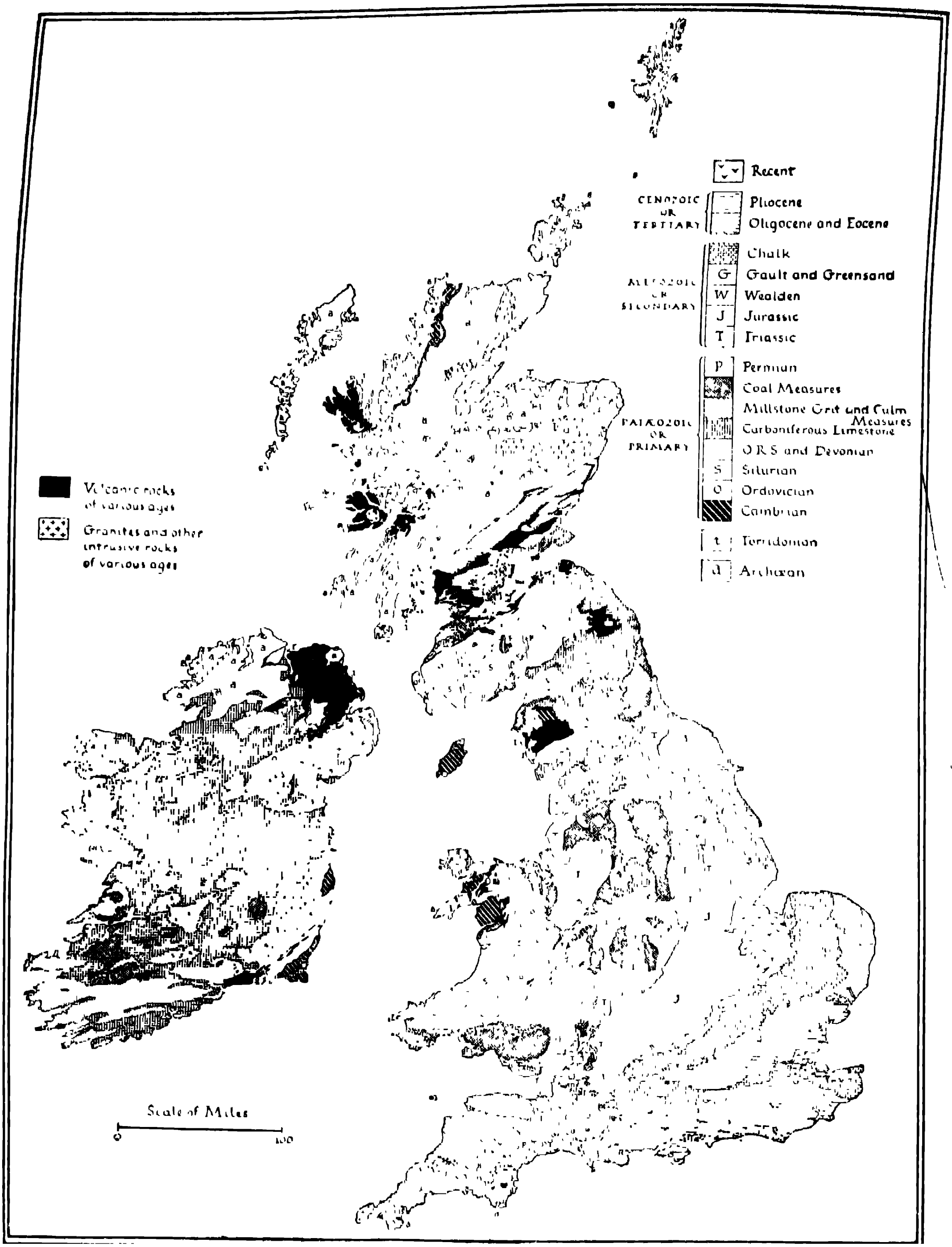
If you have worked through this Course *and know it*, you will have a knowledge of sufficient grammar for all the purposes of everyday life. What you require now is practice in reading, in order to enlarge your vocabulary. If you should wish to extend your knowledge of grammar, you must first study the subjunctive mood of verbs and its usage, which has been omitted in this course

The *Basis and Essentials of Italian* by Charles Duff (Messrs. Nelson & Sons) treats the subjunctive fully, and it may be useful to extend knowledge in other directions. Then an Italian grammar written for Italians is the best book. And *La Grammatica degl' Italiani*, by Trabalza and Allodoli, published in Florence, is thoroughly recommended.

A good Italian-English Dictionary is absolutely essential. That by A. Hoare (Cambridge University Press) can be recommended.

Reading in Italian. What to read next ? The choice is great. Italian, however, provides this surprise and delight, that the person with a moderate knowledge can plunge immediately into the greatest poetical masterpiece of the language : Dante's *Inferno*. Dent's Temple Classics edition has the Italian text and a prose translation opposite. You should study it until you can read the *Inferno* from end to end in Italian without looking at the translation. If you know an Italian, get him to keep you right on pronunciation : and learn passages by heart. This will help towards fluency in speech and fix the language for all time in your mind

Now read a History of Italian Literature. First, perhaps, the little one by Prof. Gardiner, and then a larger one, say that by Richard Garnett. You will then be able to make your own choice of reading. If you wish to tackle a good novel, then *I Promessi Sposi* by Manzoni can be recommended, for there is a translation to help you out. And you might try Machiavelli's *Il Principe*, for which there is a translation in the World's Classics series.



GEOLOGICAL MAP OF THE BRITISH ISLES

From " Britain's Structure and Scenery," by L. S. Stamp (Wm. Collins Sons and Co., Ltd., New Naturalist Series)

GEOLOGY

As presented in this Course, Geology is revealed as a study of deep and living interest. The student will learn of remarkable creatures of early geological times that lived and disappeared many millions of years ago. He will learn what the rocks and fossils reveal. Information of direct practical value is also given concerning the chalks and clays, coal, mineral, and other deposits immediately beneath the surface of the earth. Particular attention is paid throughout to the geology of the British Isles.

Certain aspects of geology lead into other subjects such as those covered by the Courses on BIOLOGY *in Vol. 1,* PHYSICAL GEOGRAPHY *and* ZOOLOGY *in the present volume, and* ARCHAEOLOGY *in Vol. 3.*

20 LESSONS

LESSON 1

Rocks: Storehouse of Earth's History and Natural Wealth

Until the 19th century most people living in Western civilization believed that the world was not more than about 4,000 years old. In that short history man had been the central figure, and it was inconceivable that there should have been a time when there were no men on the earth—that there might be a more distant time when there were no bony creatures walking on land on four legs. But from the beginning of the 19th century onwards facts have slowly accumulated which allow an immensely long history to be pieced together, a history of the changes which have affected the earth's surface down 3,000 million years.

Down the last 500 million years a record of life can be found which peoples the changing scenes of earth's history with animals, and clothes it with plants. The earliest plants and animals lived in the seas, lakes, and rivers. As the record continues the lands are colonised, more and more familiar forms of life are found, until in the last million years or so man appears, evolves his civilizations, and his influence begins to dominate the natural scene.

Foundation of Geology

This new knowledge is mainly due to the science of geology, founded at the beginning of the 19th century. Its foundation brought not only a revolution in man's views on the past, but also an increasing mastery in purely practical matters—the search for and utilisation of the immense natural resources in the rocks of the earth's crust.

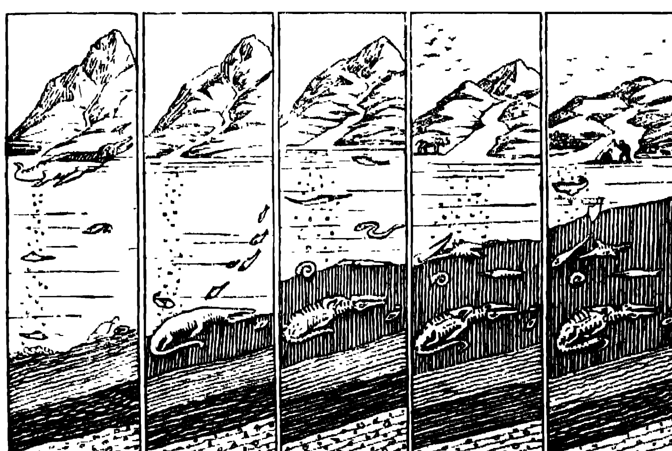
Geology became established as a science when answers had been found to certain questions. One very important question was how rocks originated, what sort of processes formed them. Anyone who has walked along a beach and looked at the rocks forming cliffs must have noticed how varied rocks are in appearance. So it is not surprising that there are a number of different ways in which rocks may be formed. One spectacular process of rock formation is seen when a volcano erupts; from its vent a mass of molten mineral matter pours out as lava, and trickles down its sides for a short time before solidifying, through being chilled by contact with the air.

Clouds of ash are belched out from the volcanic vent and settle in layers, some on the sides of the volcano, some much farther afield. Successive eruptions build up flow after flow of lava and layer after layer of ash, so that the result is a stratified cone of volcanic rocks piled up round the volcanic vent and building thinner layered deposits in neighbouring areas. Sometimes the remains of animals and plants, which were overwhelmed by lava or buried in ash, are found as fossils in the rock layers.

Reservoir Rocks

It is reasonable to infer that somewhere deep below the volcano there must be a reservoir of molten minerals to supply the eruptions. Ancient lavas and beds of ash can be recognized in areas where no volcanic activity has been known since recorded history began. And very ancient volcanoes have been dissected down to their roots by the long-continued action of weather and streams, so that the rocks of their subterranean reservoirs are exposed.

These reservoir rocks differ from lavas in many ways. They are not layered, and never contain fossils. They have cooled much more slowly than the lavas, because they were buried deep under a blanket of covering rocks, and so their minerals have had plenty of time to crystallise into large and easily seen crystals



HOW FOSSILS HAVE BEEN PRESERVED. The drawings represent the gradual denudation or wearing down of a land-mass and the consequent deposition of a series of layers, or strata, of debris on the floor of the ocean. As the result of tremendous and prolonged pressure, these became converted into rock, sealing up the skeletons, shells, etc., of primitive creatures that lived and died when the strata were being laid down.

interlocking to form mosaics of different colours. Lavas, in contrast, commonly have a dull and stony appearance, in which only a few small crystals can be seen when their glittering surfaces catch the light. One type of lava is a beautifully glossy, glass-like, black rock ; this is obsidian, which cooled so rapidly after eruption that it formed a natural, non-crystalline glass. Fragments of obsidian have very sharp edges, and so were used as tools by ancient man.

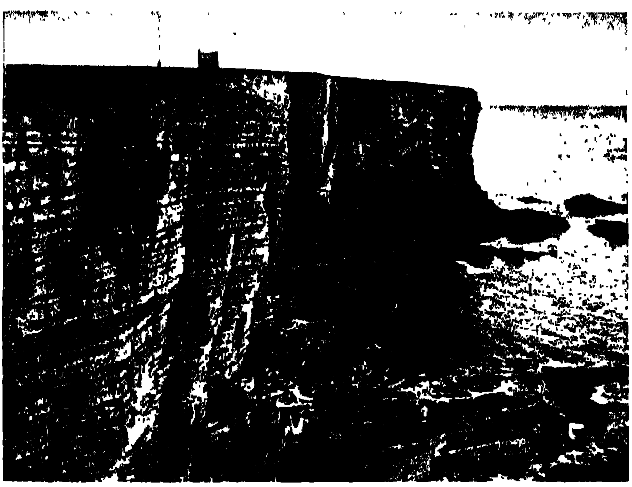
PREHISTORIC MONSTER. This fossil of a sea reptile, a plesiosaurus, was discovered in 1928 in a quarry at Harbury, Warwickshire. It is 16 ft. long, and is evidence of life in the seas long long ago.

Although the quickly cooled superficial lavas differ from the deep-seated, coarsely crystalline, reservoir rocks, because each has a different cooling history, yet both have a common origin as a mass of hot molten minerals or *magma*, and therefore are classed together as *igneous* rocks (from the Latin *ignis*—fire, i.e fire-formed). The igneous rocks are discussed in Lesson 2. Useful mineral ores, such as those of gold, lead, silver, and tin, are associated with many of the deep-seated igneous rocks.

Some layered rocks, such as sandstones, clays, and the pebbly kind of rock known to geologists as conglomerate, are formed by processes much less spectacular than those which produce volcanic rocks, processes so slow and gradual that for a long time they went unnoticed. A sandstone and a conglomerate are made up of fragments of older rocks which once formed part of a landmass. These older rocks of the more ancient landmass were attacked by weather and wind, and so began to be broken up, and worn away. The fragments were transported by wind or rivers by which, with their load of debris, continued the attack on their bedrock by abrasive action, and so added to their load. Finally the debris, rounded and ground down on its journey, reached either a big lake or, more often, the sea. There it was spread out, the coarser and heavier sands being deposited first and nearer to shore, then the finer silts, and then farthest from shore, the finest muds.

Sedimentary Rocks

These *sediments* give their name to this type of rock, the *sedimentary* rocks, which are the debris from the slow wasting away of continents, spread out in level layers or beds at the bottom of the sea or of a big lake. The attack of breaking waves, armed with sand, on cliffs, is a familiar sight, and is another means whereby land-masses are worn down and the debris spread out on the sea floor.



STRATIFIED ROCKS. These cliffs of gently-inclined thin-bedded carboniferous limestone are at Linney Head, Pembroke. The materials composing stratified rocks are various, but all are sedimentary, the layers having been deposited usually by water, more rarely by wind.

The remains of animals and plants living in the sea at the time became, at their death, buried in the slowly accumulating layers of sand and mud. Usually the soft parts of these animals rotted away, and left only the hard parts—bones or shells—to endure as a record of the life of the time. Sometimes spectacular ancient animal remains are discovered in the course of quarrying operations, such as the bones of a long-necked sea reptile with paddle-like limbs, which was uncovered in a clay pit at Harbury, near Leamington, in 1928. This creature, more than 16 feet long, was entombed in mud more than 150 million years ago.

More commonly, layered sedimentary rocks contain countless shells of marine creatures allied to modern mussels, oysters, scallops, and sea-snails. Such fossils can be obtained

from the cliffs at Lyme Regis in Dorset, the Isle of Wight, near Whitby in Yorkshire, and from many places inland, such as the Cotswold Hills and the Derbyshire and Yorkshire Dales. The processes which form sedimentary rocks, and the kinds of rock which they produce, are discussed in Lesson 3. Many sedimentary rocks have considerable economic value.

The fact that ancient marine sediments form part of a land-mass once more, and are again undergoing a slow attack by the elements, is due to their having been heaved up by earth movements, and often contorted and fractured in the process. These processes of upheaval, contortion, and consolidation of sediments, due to internal forces operating in the earth's crust, are dealt with in Lesson 4. An understanding of the way in which these tremendous forces have deformed and displaced sedimentary rocks is essential for mining engineers who may be trying to trace seams of coal or veins of ore, for prospectors looking for oil, and for civil engineers planning the site of a big new dam.

Dating the Rocks

The questions which have been answered so far, concerning the processes which form rocks, imply that the earth has an immensely long history. Slow processes of destruction have worn down former land-masses, and the layers of debris which resulted have been upheaved from the sea bottom, for the cycle to start all over again. And from the beds of ash and lava found sandwiched in between some of the sedimentary layers, can be inferred many and repeated outbursts of volcanic activity.

But a history is meaningless unless it can be dated, and unless the events taking place in different regions at the same time can be correlated as contemporary. The next question is how this can be done for rocks. It was answered at the beginning of the 19th century by William Smith (1769–1839), an engineer. As a boy, Smith had collected fossils, as curios, from the Cotswold Hills. As a civil engineer, he was engaged in canal construction, and this gave him an excellent opportunity for examining long straight cuts made through the gently tilted, layered sedimentary rocks of southern England.

Smith found that in cutting canals in different directions he could always recognize individual layers or beds of rock, in whatever district he found them, by the characteristic assemblage of fossils which they contained. In this assemblage some of the individual fossil members might also be found in the bed above or the bed below. A few were found to be present in many different beds. Others were restricted to one particular bed and no other. Always the total of the different kinds from a particular layer was different from the total found in layers above or below. Here was a means of recognizing rock layers and of correlating them. No matter how much a layer of rock had been twisted about by earth movements, one could follow it through all its contortions, establishing its identity by its fossils.

If a once-continuous layered sheet of rock had been cut into discontinuous fragments by stream valleys, the fragments appearing as cappings to the hills between the valleys, the identity of each could be established, and the inference made that once upon a time each had been in continuity with the other. Moreover, it was possible to arrange the stack of sedimentary layers in a time sequence, on the simple principle that the oldest, first-formed one lay at the bottom of the pile found at any particular place. Though any member of a stacked-up sequence might be missing at one place, it could usually be found in the sequence at another.

Sequence in Canal 1	*Sequence in Canal 2*	*Sequence in Canal 3*	*Sequence totalled from all 3 Canals*
	H		H
	G		G
F	F		F
E		E	E
D		(gap)	D
C		C	C
B		B	B
		A	A

WORN BY TIME AND TIDE. Seaford Head and the Seven Sisters, on the Sussex coast. The chalk rock forming these cliffs was deposited on the floor of an ancient sea. Now these old marine deposits are in their turn being slowly worn away by the restless sea.

Eras		Periods and Systems	Derivation of names	Max. known thickness (feet) anywhere in world	Dates in million years (approx.) of beginning of period
CAINOZOIC Kainos or Cenos = recent Zoe = life	Quaternary	RECENT OR HOLOCENE	Holos = complete; "cene" from kainos = recent. Terms refer to proportions of modern shells occurring in each system	4,000	—
		PLEISTOCENE	Pleiston = most	—	1
	Tertiary	PLIOCENE	Pleion = more	13,000	12
		MIOCENE	Meion = less	21,000	29
		OLIGOCENE	Oligos = few	15,000	40
		EOCENE	Eos = dawn	14,000	60
		PALAEOCENE	Palaios = ancient	—	75
MESOZOIC Mesos = middle Zoe = life		CRETACEOUS	Creta = chalk	64,000	135
		JURASSIC	Jura mountains	20,000	175
		TRIASSIC	Threefold division in Germany	25,000	210
PALAEOZOIC Palaios = ancient Zoe = life	Upper	PERMIAN	Permia = ancient kingdom E. of Volga	13,000	240
		CARBONIFEROUS	Coal-bearing	40,000	290
		DEVONIAN	Devon's marine rocks	37,000	320
	Lower	SILURIAN	Silures = ancient tribe of Welsh borders	15,000	350
		ORDOVICIAN	Ordovices = ancient tribe of N. Wales	40,000	420
		CAMBRIAN	Cambria = Wales	40,000	500
PRECAMBRIAN ERAS		PROTEROZOIC	Proteros = earlier	?	The oldest Precambrian rock known at present is just under 3,000 million years old.
		ARCHAEOZOIC	Archaeos = primaeval	?	

So, gradually, it was possible to construct a table showing the grand total of all the layered sedimentary and volcanic rocks of Britain. The layers were given names, and numbers of layers were grouped together into geological *systems*, which were also given names, as shown in the accompanying table. Other countries have followed Smith's lead, though much work has still to be done, especially in the large and less well explored continents.

Fossils and Evolution

The theory of evolution explains why it is that the fossils are different in different rock layers. They are the remains of living creatures, or plants, which were evolving in response to the natural selection exerted on them by their environments. Some evolved quickly, and successive forms are each confined to relatively thin layers of rocks. Others evolved more slowly, and the same form may be found in several consecutive rock layers.

This method of dating rocks is purely relative. One can say, on the fossil evidence, that this rock is Cretaceous, that another is Jurassic, and that Jurassic rocks are older than Cretaceous ones. But one cannot say how long ago in terms of *years* the formation of Cretaceous rocks began. Until the discovery of radioactivity there was no reliable method of dating rocks in years.

Radioactive Minerals

The decay of some radioactive elements occurs very slowly, and at a known rate, the end-product of their decay being a special kind of lead. By analysing radioactive minerals from rocks, and finding out how much these minerals contain of the special kind of lead due to radioactive decay, one can estimate how long it is since the radioactive mineral first crystallised out in a pure, lead-free, state in its parent rock. One can liken these radioactive rock minerals to clocks, each ticking out minute amounts of lead, the lead increasing slowly and steadily at each successive tick, down all the millions of years.

The answers to these questions concerning the correlating, dating, and origins of rocks, provided the basis of the science of Geology. It was realized that many of the processes which formed rocks are operating at the present day, and that a careful study of them would provide a means of interpreting the clues which rocks contain regarding their origin. The present is the key to the past, when reconstructing earth's history from its rocks.

LESSON 2

Volcanoes and Useful Minerals

THE kind of volcano which most people know, through pictures and films, is a conical hill, with a crater-vent at, or near, the top which periodically erupts lava and ash. This ash is not something which has been burnt, as was once thought. It originates as tiny droplets of lava, blown up into the air by the eruption, and these cool to solid particles as they fall. Some of these particles are exceedingly small, and so light that they may be blown right round the world after an explosive eruption, by the winds of the upper atmosphere.

PUMICE STONE. This familiar substance comes from lava "froth."

Another volcanic product is gas. Much of it is steam, but there are small amounts of carbon dioxide and monoxide, sulphur gases, nitrogen, and chlorine. In the reservoir of molten minerals, or magma, deep beneath the volcano, the gas is in solution under pressure, much as is the gas in a soda-water siphon. As the lava comes up the neck of the volcano and erupts from the crater, the gases are released. Sometimes this happens quickly and violently, and great clouds of ash are produced. Sometimes it occurs more gently in the lavas as they run down the volcanic hill, producing *pumice*, a light frothy lava-rock full of gas-blown tiny bubbles.

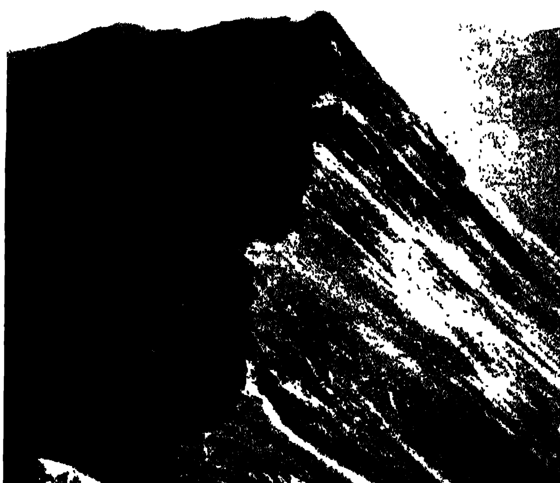
The stickier lavas, such as those called rhyolites, flow slowly, and travel only short distances from the crater; these build the steepest hills. There are more mobile lavas, called basalts, which run very freely, spreading far in thin sheets. These build low broad hills with large craters, such as those of the Hawaiian Islands. Sometimes these basalts erupt not from a localised circular vent but from very long gaping fissures. Such an eruption occurred in Iceland in 1783; three cubic miles of basalts poured out of a fissure 20 miles long, and quickly inundated over 200 miles of the country.

Degrees of Violence

Volcanic eruptions vary greatly in the degree of violence with which they occur. In Hawaii the mobile lavas erupt quietly. Stromboli, on one of the Lipari Islands near Sicily, has frequent minor eruptions, at intervals ranging from a few minutes to several hours. At the other end of the scale of violence are such eruptions as that of Krakatoa, in the Sunda Straits between Java and Sumatra. For two centuries Krakatoa had lain dormant until, in May 1883, eruptions began, first at one vent, and in the next few weeks at several more. By August a dozen volcanoes were erupting with steadily increasing violence. On August 26 eruptions began to detonate with deafening violence every ten minutes, throwing up clouds of ash to a height of 17 miles. The ash was transformed into showers of mud by steady and heavy rains, and fell on the town of Batavia (Djakarta), where the thick ash clouds rendered day as dark as night.

On the morning of August 27 four tremendous explosions occurred, so loud that they were heard 3,000 miles away, in Australia. A huge cloud of glowing ash shot up 50 miles into the air, and some of it was carried right round the world in the next few months. When Krakatoa could be approached again, it was seen that two-thirds of the island had simply disappeared. A survey of the region by geologists showed that all the magma in the volcanic reservoir had been blown out by the explosions, and the covering rocks had collapsed, leaving a huge island-rimmed submarine crater measuring four miles in diameter.

In the waning stages of volcanic activity, or



HELVELLYN, on the borders of Cumberland and Westmorland, is a mighty memorial of the enormous volcanoes that existed in the Lake District during the Ordovician period.

Photo, G. P. Abraham

RELIC OF VOLCANIC ACTIVITY. Dungoyne Hill, near Stirling. Its stumpy cone, worn down by weather, is the lava plug that once filled the vent of a volcano in early Carboniferous times.

in regions where volcanoes are dying out, hot springs and geysers abound, as in Iceland and New Zealand, and hot gases may be emitted from blow-holes in rock.

Volcanic Activity in Britain

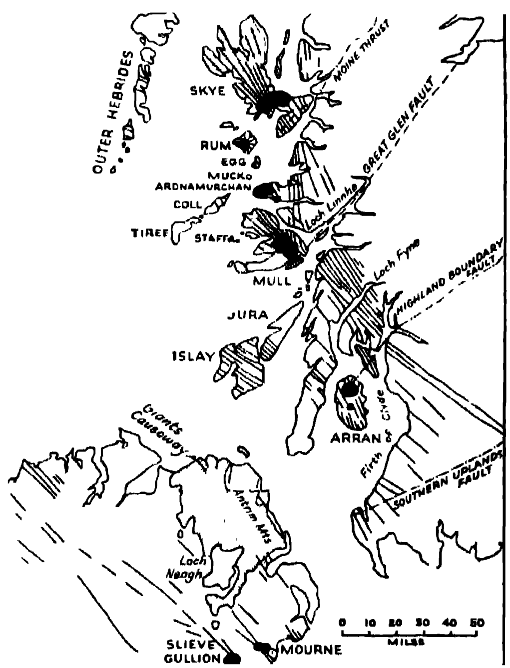
At many times in the past Britain has been the scene of outbursts of volcanic activity. In Ordovician times the Lake District and Wales were the chief centres. From Coniston Old Man to Scafell the more jagged peaks of the Lake District are carved out of the hard layers of lava and ash erupted in Ordovician times, and reaching a thickness of 10,000 feet. In Wales volcanic activity began at the sites of Rhobell Fawr and Cader Idris. Then other volcanoes began to erupt in the Aran Hill and Arenigs ; and in Upper Ordovician times there was a tremendous outburst in the Snowdonia region, piling up lava and ash to a mile in thickness. Some of the finest and most dramatic scenery in Wales, as in the Lake district, is due to the resistant nature of these old volcanic rocks.

The next major outburst came in Devonian times, chiefly in Scotland. In places it continued in early Carboniferous times. The Devonian eruptions occurred from volcanic cones bordering the Scottish Lowlands to the north and south, the cones being situated in rows along lines of dislocation in the rocks below. Flows of lava and ash from the northern volcanoes occur in the Ochil and Sidlaw hills, and the southern ones contributed to the rocks which now form the Pentland hills. Farther to the north, in Glencoe and Ben Nevis, and to the south in the Cheviots, relics of these dramatic Devonian events may be found. The actual volcanoes can be traced in the case of the early Carboniferous outbursts ; for as volcanic activity ceased, lava cooled in the supply pipe to the crater and can now be seen as plug-like masses, partly uncovered by the action of weather and streams, at Dungoyne Hill, near Stirling, at Arthur's Seat, Edinburgh, and at Meikle Bin, near Glasgow.

Basalt Lava

Submarine eruptions occurred in the Devonian and Carboniferous seas which covered Cornwall and Devon at the time. As the lava erupted into the sea, it balled up, much as a stream of hot toffee does when poured into cold water. The balled lava flows resemble heaps of pillows, and so are called pillow lavas.

Cambrian and Silurian times had been quiet periods in the history of British volcanicity, and no volcanic activity took place during any of the Mesozoic periods. In early Tertiary times relatively short but tremendous volcanic activity occurred in western Scotland and north-east Ireland. The results are magnificently displayed in the hills of Ulster and the Hebrides, where subsequent weathering has carved out these hills



EARLY TERTIARY VOLCANOES of Scotland and Ireland, with their swarms of dykes, are shown in this map. Lavas are stippled. Reservoir rocks are black.

From "The Petrology of the Igneous Rocks," by Hatch, Wells, and Wells (Allen and Unwin)

from the volcanic rocks, dissecting the old volcanoes so that both lavas and subterranean reservoir rocks can be seen.

Most of the lavas are basalts, some extruded from fissures, others from volcanic pipes with a central crater-vent, as on the island of Mull. Mull resembled the present-day volcanoes on Hawaii, such as Kilauea, a broad, gently rising cone with a large crater. Similar volcanoes occurred on Skye, Rum, Ardnamurchan, and Arran, and at Mourne. Sometimes the basalt-flows, when they cooled, cracked into hexagonal or polygonal pillars, as at Fingal's Cave on the island of Staffa, and at the Giant's Causeway in Northern Ireland. On Mull the remains of an Eocene age forest have been found engulfed in a lava flow.

The mobile basaltic lavas were not all erupted at the surface. Some forced their way into cracks and planes of weakness in the surrounding rocks, penetrating for very long distances from the sites of the eruptions. These form hard wall-like "dykes" of basaltic rock, contrasting in their upright attitude and distinctive rock-type with the sedimentary and other rocks into which they intruded themselves.

Sulphur and Bentonite Deposits

Similar volcanic activity was occurring in early Tertiary times in Iceland, Spitsbergen, and the Faroe Islands, and this activity has continued down to modern times in Iceland. In Britain, vulcanicity ceased at the end of the early Tertiary and has never been resumed. A survey of ancient vulcanicity throughout the world brings out an interesting and important fact : basalts are by far the commonest volcanic rocks, outnumbering all others in sheer bulk, and in frequency of occurrence.

Useful deposits of sulphur may occur as the result of the action of hot gases and springs in the waning stages of volcanic activity, and such deposits are found on the Lipari Islands near Sicily. Bentonite is a substance rather like fullers' earth, has important absorptive properties, and so is much used in various refining processes. It was originally a fine volcanic ash, which has decomposed to a clay-like substance. Rich deposits of bentonite occur in the western states of the U.S.A.

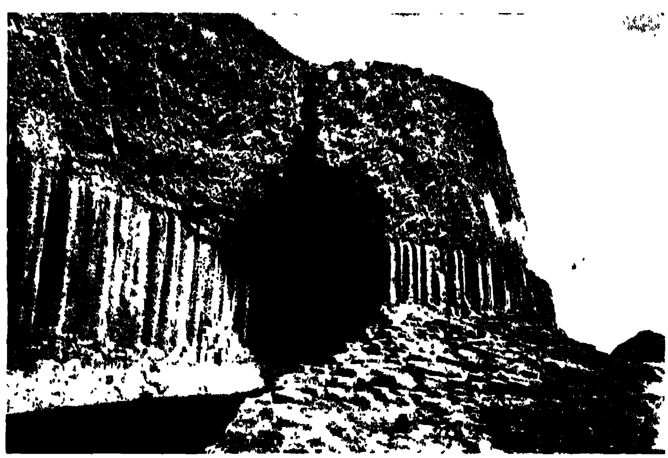
Copper Deposits

In some areas the gas-blown bubbles of basalt lavas are found to be filled with metallic copper, as in the Faroes and near Stirling in Scotland. Such deposits are only occasionally rich enough to be worth working, as in the Keweenaw peninsula of N.W. Michigan, on the south shore of Lake Superior. Here the basalt flows are Precambrian in age, and the richest source of copper in the U.S.A.

Other deposits of economic value associated with volcanic rocks are few. More occur in association with the subterranean reservoir rocks (*see* later paragraph). It should be remembered that volcanic action brings up from the depths of the earth new supplies of water, to be put into circulation in the atmosphere, streams, and oceans ; and new supplies of chemicals in the form of minerals. These minerals, when broken down by chemical decay due to the continuous attack of weather and ground water, form the ultimate new resources of chemical nutrients for the plant and animal world, and so are important in the natural economy of the earth.

Granite

A familiar example of a subterranean, or deep-seated, igneous rock is granite, whose interlocking crystals form a mosaic of black, white, pink, and grey. This hard, compact rock takes a good polish, and so is often used as an ornamental stone facing for buildings. It is found in the natural state in large, unstratified masses in some parts of Britain—on Dartmoor, on Shap Fell, near Aberdeen, and at other places. The granite at Shap Fell was originally covered by 10,000 feet of stratified rocks of Lower Palaeozoic age. This deep-seated cooling has been responsible for the formation of fairly large crystals in the Shap, and in all other granites, and contrasts with the condition in lava rocks.



ANCIENT VOLCANIC ROCK OF SCOTLAND. Fingal's Cave, on the island of Staffa, Inner Hebrides. Here erupted basalt lava, cooling as it ceased to flow, cracked into hexagonal or polygonal pillars. The cave is 227 feet long. Its entrance is 42 feet wide and 66 feet high. It is remarkable not only for its pillars but also for the wonderful play of colours from the surface of the sea which forms the cave's floor.

There are other features which distinguish igneous rocks from one another besides their cooling histories. One most important distinction is their chemical and mineral composition. All igneous rocks consist of minerals which are mainly silicates of various metals, though oxides and sulphides also occur. Igneous rocks differ from one another chiefly in the *proportions* of the various chemicals which they contain.

Quartz

For example, granite is relatively poor in iron and magnesia, rich in silica and aluminium. Indeed, granites contain so much silica that there is some left over after all the various metallic silicates have been formed. This excess silica crystallises out as its pure mineral form — quartz, which can be seen as dull, glassy-grey crystals in granite rocks. The chemical equivalent of granite among the lavas is rhyolite, which is greenish or pinkish in colour: granites represent the reservoir rock below old volcanoes which had rhyolite lavas.

Basalts are relatively rich in iron and magnesia, poorer in silica and aluminium, and they have a deep-seated reservoir rock called gabbro. Gabbros, being poorer in silica, never have enough over after the metallic mineral silicates have been formed to crystallise out as quartz. They are black and white crystalline rocks, lacking the dull glass-grey crystals of quartz, and also the pink ones seen in some (but not all) samples of granites.

These differences between igneous rocks can be summarised in a simple table:

	Chemical differences	
Differences in cooling history	Rich in silica and aluminium Poor in iron and magnesia	Rich in iron and magnesia Poor in silica and aluminium
Superficial (lavas, few crystals) quickly cooled	Rhyolites	Basalts
Deep-seated (reservoir-rocks, wholly crystalline) slowly cooled		Gabbros

Many more useful mineral ores are found associated with the deep-seated igneous rocks than there are with lavas. Since the deep-seated igneous rocks vary in chemical composition, it is not surprising that the types of mineral ore found associated with gabbros and allied rocks differ from those found with granites.

Iron and Titanium Ores

When a big mass of molten minerals is cooling slowly underground, the heavier crystals, as they form, may sink towards the bottom of the mass. So in gabbros and allied rocks, iron and titanium ores are found concentrated in local layers and clots, and this useful natural concentration makes them worth working; otherwise the ores would be scattered in small amounts through the whole rock-mass. In other cases, while the huge molten mass is cooling, cracks may open in the surrounding rocks and the more mobile solutions and vapours find their way along these cracks to form *veins*. Thus, around some granite masses, for example, veins are found radiating from the parent rock-mass. Such veins contain mineral ores of tin, lead, copper, and some other minerals.

Concentration of Gold

The old-time miners "panned" for gold. They stood in a stream, and scooped up gold-bearing sand or gravel into a shallow dish. By swirling the water around in the dish they got rid of the lighter sandy and pebbly material and kept the heavier gold in the bottom of the dish. Those miners were completing a natural process of *concentrating* the valuable metal, a process which had been begun by weather and stream. For the weather had attacked the gold-bearing rock and decayed it, though the gold itself was resistant to chemical decay. Rain and stream concentrated the metal into the local stream beds, and the metal, being heavy, tended to remain in the stream beds while the lighter sands were washed on and down towards the sea. Several useful metallic minerals which are resistant to weathering, such as platinum and tin, are found in workable deposits, thanks to such processes of natural concentration by weather and streams; and so are many precious stones.

A proper understanding of the formation of mineral ores, and the way in which they are likely to be found in workable deposits, requires a knowledge of physics, chemistry, and geology. Such knowledge, applied by trained geologists, has replaced the rule-of-thumb and hit-or-miss methods of the old-time miners in prospecting for new supplies of useful minerals from the rocks of the earth's crust.

LESSON 3

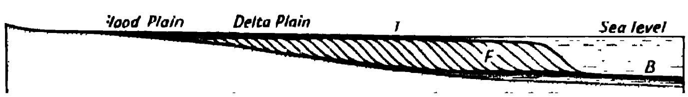
Sedimentary Rocks, Ancient Deltas, Reefs, and Forests

The less spectacular processes which form sedimentary rocks start with the *destruction* of an older rock mass on land, continue with the *transport* of the debris by water or wind, and end with the *deposition* of the debris in an inland lake or the sea.

Destruction of rock masses on the lands is due to weathering. In hot, arid climates the rocks are chiselled away by the extreme temperatures. Rocks are bad conductors of heat ; only the outer " skin " of rock becomes heated up by the sun, and as it heats up it expands and cracks away from the cooler rock below. Temperature changes continue to fragment the chiselled-off pieces. At night, in hot, dry climates, the temperature often drops rapidly, and the rock fragments swiftly contract, and crack, often with noises like pistol shots.

Erosion Forces

In cold climates another form of chiselling occurs. As water freezes it expands, and so rock masses are broken up by alternate freezing and thawing of water in crevices. In warm or hot climates with a moderate to high rainfall, chemical decay is active in rock destruction.



SECTION THROUGH THE SEDIMENTS OF A DELTA.
T, topset beds ; F, foreset beds ; B, bottomset beds.
From " Principles of Physical Geology," by A. Holmes (Nelson)

Rainwater containing dissolved oxygen and carbon dioxide, and ground water containing the humic acids due to plant decay, attack many of the minerals in igneous and other rocks, breaking them down into clay-mineral substances. Clay minerals are complex combinations of alumina, silica, iron oxides, and water. Those minerals which are more resistant to chemical decay, such as quartz, are released as the other minerals crumble to clay, and they and the clays are washed into the nearest stream.

The action of the weather in destroying the rocks of land-masses is continued by streams and rivers, by waves breaking against cliffs, and by the scouring action of wind in deserts. These *erosion* forces (from the Latin *erodere*—to gnaw away), which help to level the lands, are also the transporting agents of the debris. Eventually the debris comes to rest in a large inland lake or in the sea, and as a rule it is spread out in horizontal layers. Locally the layers may be inclined at an angle, rather than horizontal. This inclination happens on a fairly large scale in river deltas.

Deltas are formed by a process of tipping, rather like that which forms a colliery slagheap : truck-loads of rubbish are dumped at the end of such a tip, and fall down its sides form to successive inclined layers. A delta is built in much the same way ; at each flood period the river brings down a great load of erosion debris, and as soon as the river current reaches the open waters of the sea, its speed slackens and it dumps most of its load as an inclined layer called a forest bed. A little of the finer debris is carried beyond the delta tip-heap and spread farther out in horizontal layers of mud (called bottomset beds), and in non-flood periods mud is laid down on top of the delta (called topset beds), some of which may be scoured off at the next flood period.

Tiny irregular delta building goes on in shallow seas wherever the speed of a current is checked by its reaching a deeper water area. In desert areas a similar sort of process is carried out by wind in heaping up sand dunes. Examples of water and wind " tipping " can be seen at a number of places in Britain. At Wollaston Ridge, near Stourbridge, Worcestershire, sand dunes of Permian age can be seen cut across so that the inclined bedding planes are well displayed. The Upper Carboniferous age millstone grit is an example of a large British delta ; its deposits can be seen at many places in the Pennines.

Conglomerates

Erosion debris forms rocks of various kinds. Pebbly rocks are called *conglomerates.* An examination of the pebbles provides some clues as to the way in which these rocks were formed. If the pebbles are angular fragments, this suggests that their journey to their resting place was too short for them to have their corners knocked off in transit. Often such conglomerates with angular pebbles are ancient screes, such as those of Permo-Triassic age which are banked against the Mendip hills of Somerset, and which may be seen used as building stone in the city of Wells.

Other conglomerates have well-rounded pebbles, and these are often beach deposits, as those of Eocene age at Blackheath near Londont and those of Liassic age north of Shepton Malle,

in Somerset. Others are river deposits, such as those at Budleigh Salterton in Devon, and those in the Midlands, around Stafford, Derby, Stoke, and Worcester, all of which are Permo-Triassic in age. The pebbles may also provide clues to the geography of the period, if the materials of which they are made are analysed.

Sand

Sandstones also contain clues as to their origin. If the sand grains are very well rounded and have a surface which is etched like frosted glass, then they were formed in desert areas and owe their perfect rounding and etching to the scouring action of wind. Beach sands are also rounded, but never so perfectly as those of deserts, nor are the grains etched. If the sand grains are unworn and angular, then they have had a quick journey to their resting place, and they form a rock called *grit* or *gritstone*.

Most conglomerates, and sandstones and their finer-grained varieties the *siltstones*, are hard rocks because their sands and pebbles have been cemented together. To understand the nature of this cementing process we may consider another type of rock formation—*stalactites* and *stalagmites*. These are known to most people who have visited caves in Somerset, as at Cheddar and Wookey, and in Derbyshire and Yorkshire. In these caves the stalactites form curious shapes and pillars, and encrust the cave walls. They are formed by the slow dripping of lime-laden water, which percolates down through the roof and walls, and as it reaches the cave and falls in drops, the water evaporates and the lime crystallises out. The stalactites are thus constructed from innumerable tiny additions of lime crystals made over a very long period of time.

From Clay to Slate

When pebbly or sandy deposits are laid down, lime-bearing waters may percolate through them, depositing lime in the crevices between the pebbles and sand grains. Sometimes the ground waters contain silica in solution, and deposit crystalline quartz. In this way loose sands and pebbles become cemented together, sometimes patchily, often very completely to form a hard rock. When a sandstone or siltstone splits easily along its original planes of layering or bedding, it is called a *flagstone*. When it is well cemented and can be cut or split with equal ease in any direction, it is called by the quarrymen a *freestone*.

After deposition, the finer muds gradually loosen a great deal of their contained water, and become clay. Further compression, under the weight of the pile of beds added above, squeezes out more water and results in a *shale* or *mudstone*. A shale has the property of splitting along the original planes of bedding, which are set fairly close together. A mudstone lacks this property. If clay rocks are subjected to great pressure by earth movements, they may be transformed or *metamorphosed* into *slates*. A slate can be split into very thin parallel layers but, unlike a shale, these are not usually along the original bedding planes.

The new splitting planes are due to the effects of intense pressure, which has caused the minute flakes of the clay minerals to orientate themselves perpendicularly to the direction of pressure. Because the tiny clay mineral flakes have been made to lie parallel to one another, in one direction, the rock can now be split in this direction. A " grain " has been imparted to the rock ; and, as with wood, it is easier to split the rock along its grain than across it. Slates are of considerable economic importance, and are obtained from Cambrian age rocks in north-west Wales, and from Ordovician rocks in the Lake District, and from a few other areas.

Lignite and Coal

So far we have considered the fate of the visible load of debris borne by a stream, its deposition, and its conversion into various kinds of rock. Streams also bear an invisible load of soluble chemical salts, formed by the chemical decay of rocks, particularly igneous ones. Eventually these salts reach the sea ; at present they are doing so at the rate of hundreds of millions of tons a year. Yet the sea is not getting appreciably saltier, so these salts must be used up in some way, and this is mostly done by marine organisms of various kinds. Lime salts are used by various kinds of animals to build protective shells, and silica is used in the same way by such organisms as diatoms and glass-sponges. Other salts are used as food by seaweeds and vegetable plankton, and part of a stream's chemical load is retained on land as food by land plants.

These organisms, dependent on supplies of chemicals from the breakdown of rocks, may themselves be rock formers. On land, vegetation may accumulate in thick layers, normal bacterial decay being arrested because the plant remains become waterlogged on falling to the ground. Gradually the vegetation layers lose water and various gases, as further sediment is piled up above them. As compression continues and increases over long periods of time, the continued loss of water and gases consolidates the vegetation, first to *lignite*, a rather charcoal-like rock (though less dry and powdery), and then eventually to *coal*.

Formed by Marine Organisms

Other organic sedimentary rocks are formed by the hard parts of marine organisms. Corals, moss-animals (bryozoans), and lime-secreting algae build reefs. Shells form shellbanks, and

the minute hard protective cases of the unicellular animals and plants form oozes of various kinds. All these are found consolidated as rocks of various ages, except the oozes formed at the bottom of the deep oceans and which are rarely present in the rock-record of the continental areas. Most of the sedimentary rocks of all geological ages found on the world's continents were laid down as shallow water marine deposits or as terrestrial deposits.

Evaporites

One other fate can befall the chemicals borne in solution by rivers to the seas and inland lakes. They may form a group of sedimentary rocks which are classed together under the expressive name of *evaporites*. Under special conditions, one of which is an arid climate, lakes, or sea-water in shallow lagoons, may undergo a high rate of evaporation, so that the chemicals in solution are precipitated and accumulate on the bottom as a fine mud. The least soluble chemicals are precipitated first, lime being the first to form a mud, which consolidates to *limestone*. Next to precipitate is calcium sulphate, which forms the rock called *gypsum*. With a high degree of evaporation, sodium chloride, or common salt, is formed. Last, and more rarely, the very soluble salts of potash may be precipitated.

The evaporites are of great economic importance to man. The commonest is limestone, which may be partly of organic origin, and which is much quarried in Great Britain. The hard carboniferous limestones are the most quarried, for road-metal, for use in smelting ores in blast furnaces, and for burning for lime. Gypsum is less commonly found in workable quantities, but it occurs near Durham, together with salt, both of Permian age. At Chellaston near Derby, and at Tutbury in Staffordshire, occurs a crystalline form of gypsum, of Permo-Triassic age, which will take a high polish and is used as an ornamental stone called *alabaster*. Salt deposits 800 feet thick, of Triassic age, are the basis of an industry in Cheshire.

Fossils

Although fossils sometimes occur in lavas and ash beds, the majority of them are found in sedimentary rocks, though rarely in any of the evaporites except limestones. Most fossils are the hard parts of animals, and the more durable woody and cellulose tissues of plants. Occasionally, exceptional conditions of preservation, which naturally include a quick burial, may allow traces of the soft parts of animals to be fossilised. Dinosaurs have been found with the skin preserved, and in North America a fine black shale of Middle Cambrian age has preserved numbers of soft-bodied marine animals as thin films of carbon.

Sometimes a shell or a bone is buried in sand, and then the lime of the shell, or the bone substance, is leached away by percolating waters, leaving a natural mould from which a cast can be taken by using plaster of paris or rubber latex. Occasionally a natural cast may be formed as percolating waters bring other substances, such as silica, to fill the mould.

Footprints

Another type of fossil is the imprint or footmark of an animal. A footprint may be made in soft mud, baked hard by the sun, and then filled in with sediment and buried at the next rains. The study of fossils is called *palaeontology*, and some of the best palaeontological work on British fossiliferous rocks has been done by amateurs in their spare time.

LESSON 4

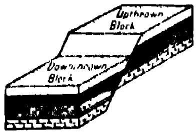
Earth Movements and their Effects

At present, as in the past, the lands are being levelled by erosion. Down the enormous length of geological time, they would long ago have been reduced to low monotonous plains but for the intervention of earth movements. These have squeezed the sediments and volcanic rocks laid down in former ages, buckling them into folds, displacing and fracturing them, and have then heaved them up to form mountains and plateaux.

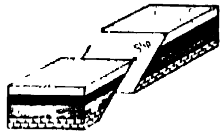
Joints and Faults

The effects of earth movements can be seen at many places in Britain. In almost any quarry or natural rock exposure of any size, the layered rocks are seen to be cut up by a system of cracks, called *joints*, which are often perpendicular to the bedding planes. The characteristic feature of a joint is that there has been no displacement on either side of it. Joints constitute a regular system of cracking planes in rocks.

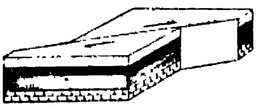
A *fault* differs from a joint in that the rocks have been displaced on either side of it. The ways in which rocks may have moved along a fault plane are shown in the four diagrams. They are commonly thrown vertically downwards or upwards in a normal fault, or they may slide sideways past one another to form a tear fault. More rarely, one block of rocks may toboggan forwards over another block in a thrust fault. Faults are one of the factors which



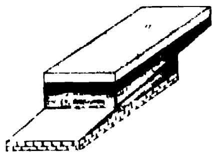
FAULTS. The relative movement involved in a normal fault. Part of the fault plane is left unshaded.



Oblique-slip normal fault, illustrating the meaning of the term slip.



Tear fault; also known by the terms transcurrent or strike-slip fault.



Reverse, or thrust fa
From "Principles of Physical Geology" by A. Holmes (Nelson)

complicate mining operations. A miner working along a seam (or bed) of coal may suddenly find that it has disappeared and he is cutting into a different kind of rock. The coal seam has been displaced, usually upwards or downwards, by a fault, and the problem is to find the seam again.

The geologist gives guidance in the search for the seam. He must have a thorough knowledge of the sequence of beds in which the coal seam occurs, be able to identify each bed by its contained fossils, and know the thickness of each bed. He examines the unexpected bed of rock into which the miner has cut, recognizes its position in the coal-bearing sequence, and can then direct how far up or down a shaft must be cut to find the seam again.

Over much of eastern England the Mesozoic rocks are gently tilted south eastwards. In other areas, such as Wales, Somerset, and the south coast, the rocks have been buckled into folds. An upfold is called an *anticline*, and it always has the oldest, originally lowest, bed of rock in its central core, the younger ones on the periphery. An anticline is exposed in cross section at Lulworth Cove. In other areas the anticlinal upfold may have been worn down by erosion, exposing ribbon-like outcrops of rock inclined, or *dipping*, away from the central core of oldest rock.

Anticlines may lean at any angle, or even lie on their sides so that their limbs lie one above the other. The angle at which an anticline lies can be most readily described by imagining a plane which bisects the limbs of the fold, and measuring the inclination of this axial plane. Some anticlines have limbs which run parallel to one another for long distances, like the arch of a railway tunnel. In others the limbs run together, forming an oval or half-egg-shaped fold, or the fold may be dome-shaped like an inverted pudding basin. When the limbs of an anticline run together, they are said to *pitch*.

Synclines

The opposite type of fold to an anticline, a downfold, is called a syncline, and it has the youngest, originally uppermost, bed of rock in the centre of the fold. If the diagram of the anticline is turned upside down, it forms a syncline, but then the blacked-in rock layer at the centre of the fold will be the youngest rock. Like anticlines, synclines can lie at any angle.

Folds are extremely important in the practical aspects of geology. The preservation of some of Britain's coal-bearing rocks is due to the formation of synclines, as described in the Lesson on the Carboniferous rocks. Anticlines are important to oil prospectors. In whatever rock oil may be formed it usually seeps into the nearest porous rock, such as a poorly cemented sandstone. In this reservoir rock it slowly accumulates, together with water. As oil is lighter than water, it tends to work its way upwards and form a layer lying on top of the water in the upper part of the sandstone bed.

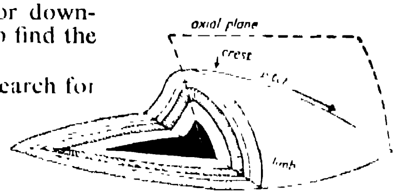
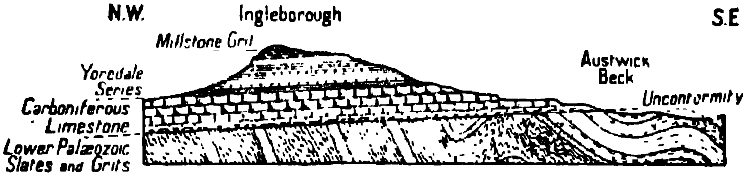


DIAGRAM OF AN ANTICLINE

AN ANTICLINE is exposed in cross-section in the cliffs at Lulworth Cove, in Dorset. In this photograph a steamer is seen about to enter the cove, a circular bay about 500 yards across.



SECTION across Ingleborough and its foundations, in the Settle district of Yorkshire, showing the unconformity between the Carboniferous beds above and the intensely folded Lower Palaeozoic strata below. Length of section equals four miles.

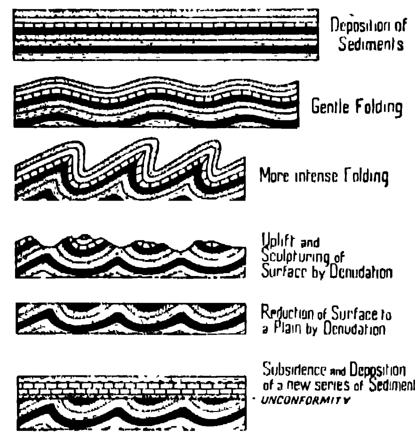
All diagrams in this page from "Principles of Physical Geology," by A. Holmes (Nelson)

The richest accumulations of oil occur where the sandstone layer is bent into an anticline, for the oil collects at the top of the hump or crest of the anticline, particularly if the sandstone reservoir rock is sealed off above by a clay layer. The oil prospector looks for these anticlinal "humps," or similar structures in the layered sedimentary rocks, and puts down a bore to tap the underground crest of the fold. There is very little oil in British rocks, but a small steady supply is obtained from the Eakring district of Nottingham.

Unconformities

That earth movements have operated many times to raise former sea-beds to form land areas can be seen by studying *unconformities*. An excellent example in Yorkshire is illustrated in the diagram at the head of this page. It shows the sort of relationship between two groups of rocks which can be seen in many quarries and natural exposures in the region of Ingleborough. Horizontal layers of Carboniferous-age marine limestone rest on upturned and bevelled edges of highly inclined marine Silurian flagstones. The plane of discordance between the two groups of strata is called an unconformity, and at its position there is also a big time gap—the whole of the Devonian period, which is not represented by deposits of any kind. The same sort of relationship exists between the Carboniferous and Lower Palaeozoic rocks throughout the district.

The meaning of the unconformity in terms of the history of the area is shown in the lower diagram. First, the Yorkshire area lay below the sea in Lower Palaeozoic times, and a series of muds and grits accumulated on the sea floor. Then these sediments were affected by earth movements, folded, and lifted up to form a land area. Erosion and weathering, or denudation (from Latin *denudo*—I make bare), wore down the folds of the land area, presumably during Devonian times. When



UNCONFORMITY. Diagrams illustrating successive stages in the development of an unconformity.

the land area had been worn low, slight subsidence brought the seas in over the district once more, and marine limestones and deltaic deposits were laid down there in Carboniferous times. Subsequently the district has been uplifted to form a land area for a second time, and is now being worn down once again.

LESSON 5

The Structure of the Earth

The layered sedimentary and volcanic rocks form a thin veneer of variable thickness over the earth's surface, and granite masses intrude into these surface deposits. Below the sedimentary rocks lies the great bulk of the earth's mass, a huge ball nearly 8,000 miles in diameter. The ball is slightly flattened at the poles, and it bulges a little at the equator. Its diameter, from pole to pole, is 7,900 miles; the equatorial diameter is 7,927 miles.

On a ball of this great size even the greatest mountains and ocean depths seem mere wrinkles, with Everest, the highest mountain, standing over 29,000 feet above sea-level, and the deepest ocean trench (Swire Deep, off the Philippines) reaching over 34,000 feet below sea-level. Everest and Swire Deep are exceptional in their relief, for the average height of the lands is 2,700 feet, and the average ocean depth is 12,460 feet below sea-level. Seventy per cent. of the earth's surface is sea and ocean, and only 30 per cent. is land.

The interior of the earth can be explored by a number of methods, and most of these give some information about the structure of the outer zones. First, the kinds of igneous rocks and their distribution at the surface may be considered, for it is reasonable to infer that they are samples, brought up by eruption and intrusion, of materials which exist deeper down in the earth. By far the commonest igneous rocks are those discussed in Lesson 2, particularly the basalts and the granites.

Behaviour of Earthquake Waves

Other types of igneous rock, intermediate between the rhyolites and basalts, and the granites and the gabbros, do exist but are relatively rare. The distribution of the basalts and granites over the world's surface is interesting and significant. Basalts occur all over the world, on the continents and the islands adjacent to them, and even on the islands in the middle of the deep oceans. Granites are found on all the world's continents and neighbouring islands, but they are absent from the islands of the deep oceans. This distribution of the igneous rocks suggests that there may be two layers in the outer part of the earth's interior, a deeper, world-encircling layer of basaltic material, and above this a discontinuous layer of granite rock, present under the continents and shallow seas but not under the deep oceans.

Basaltic rocks are denser than granite ones, so slabs of the discontinuous lighter layer rest on the continuous denser one. These layers have been given names which are an abbreviation of their chemical character. Granites are SIlica-ALuminium rich rocks, so the granitic layer is called the SIAL. Basalts are SIlica-MAgnesia rich rocks, and the basaltic layer is called the SIMA.

This suggestion that the outer part of the earth's interior is layered has been confirmed by study of the way in which earthquake waves behave on passing through the earth. The waves are bent (or refracted) on passing from one layer to the other, because the layers are of different densities. Earthquake waves confirm that these layers have the densities of granitic and basaltic rocks, and that the granitic sial is absent over the deep ocean floors. The behaviour of earthquake waves also allows the depth of the sial and sima to be estimated, and even provides information on the deeper levels of the earth's interior. This information can be summed up as follows:

Thickness	*Layer*	
Down to 0 10 km.	Sedimentary	*Superficial*, variable in thickness
10-15 km. 20 30 km.	Sial (granitic) Sima (basaltic)	*The earth's crust*
	discontinuity	Change in physical state of basaltic material to more plastic
30 2,900 km.	Basaltic	*Intermediate zone*
2,900 km. to centre of earth	Iron, with a little nickel	*The earth's core*, perhaps in a liquid state.

A study of the earth's gravity field suggests that the sial and sima are in equilibrium, that the slabs of sial can be envisaged as floating on the denser sima below. If the continents and their shallow sea areas are imagined as light rafts of sial floating on the denser sima, then one characteristic feature of the earth's major relief is explained: the fact that there are two average levels—one of 2,700 feet above sea level over the continents, which represents the average height at which the sial rafts float above the sima; the other of 12,460 feet below sea level, which represents the general level of the sima layer found under the oceans.

The earth's main mountain chains are also an expression of the structure of the crust. Just as icebergs floating in the sea have a submerged and hidden root-mass of ice which buoys them up, so mountain chains have a submerged keel-like root of light sial which, bulging down into the denser sima below, buoys them up and is responsible for their elevation above the general level of the continents. These deep roots are formed by the earth movements which squeeze and buckle the more superficial sedimentary rocks, for at the same time the compressive forces buckle the sial layer downwards to form the mountain root.

LESSON 6

The World's Oldest Rocks

THE oldest rocks which contain numerous fossils are those called Cambrian, and their formation began about 500 million years ago. Below the Cambrian lies a huge complex of rocks that are obviously older still, and which are almost completely devoid of fossils. A few structures, which may be fossils, have been reported from these Precambrian rocks. Most have proved to be inorganic structures, but occasionally worm trails have been found, and the remains of algae which secrete a limey covering and so tend to resemble small fossilised cabbages.

The formation of the Precambrian rocks probably took six-sevenths of geological time, for the oldest of them, only recently dated, is just under

3,000 million years old. The absence of fossils means that it is possible to work out the events and history of this long era of time only locally. Correlation of beds of rock of Precambrian age in different areas is impossible except in those cases where radioactive minerals are present. Even locally the geologist finds it is difficult to read the sequence of layers, for often these are so disturbed by earth movements that they stand on end or are badly contorted.

Metamorphosed Sediments

Wherever they occur, one can divide the Precambrian rocks into two distinct groups. There is an older, lower group, called Archaeozoic, which are completely crystalline but which rarely resemble the igneous rocks characteristic of later times. So at one time it was thought that the Archaeozoic rocks were the original crust formed when the earth first cooled. Detailed studies have shown that this is not the case. Archaeozoic rocks consist of both sedimentary and igneous types, but these have been profoundly altered by heat and enormous pressures due to earth movements.

What were once clay-rocks, such as shales and mudstones, have been transformed by heat and pressure into laminated crystalline *schists*, which often have a shining silvery look, due to the presence of sheets of white mica. More iron-rich clay layers have been metamorphosed or transformed into darker bands full of the blackish, iron-rich mica called biotite. Sandstones have recrystallised into hard, tough, grey-white quartz rocks, and limestones have been metamorphosed into compact crystalline marbles. The marbles may be beautifully streaked with colour, due to impurities once present in the limestone. Similarly the presence of such impurities as iron and lime in the former shales and sandstones have produced crystals of such minerals as garnet, now found scattered through the schists and quartz rocks.

Processes 3,000 Million Years Old

In some of these metamorphosed sediments traces can be found of pebble-beds, ripple marks, and the cross-bedding due to deposition by water currents. These all show that the metamorphosed sediments were originally deposited by exactly the same processes which formed the sedimentary rocks of later times. The Archaeozoic rocks are not the original crust of the earth, but they show that the same processes which are still at work forming deposits on the bottom of the present day seas and lakes were operating in much the same way 3,000 million years ago.

Above the recrystallised and sometimes highly contorted rocks of the Archaeozoic group lie those of the second, younger group, the Proterozoic. These form a complete contrast with the rocks below, being unaltered sedimentary and volcanic types often little disturbed by earth movements and resembling, except in the virtual absence of fossils, similar rocks of Cambrian and later date.

The largest outcrops of Precambrian rocks occur in Scotland ; smaller ones are found in Anglesey and north-west Wales, in Pembrokeshire, in an area just south-west of Shrewsbury, and in small areas in the Midlands (e.g. Charnwood Forest, and Nuneaton), and in south Cornwall and Devon.

Oldest Landscape in Europe

In Scotland and near Shrewsbury both Archaeozoic and Proterozoic rocks can be found. In Scotland the oldest Archaeozoic rocks are called Lewisian, because they are well seen on the island of Lewis in the Outer Hebrides. Lewisian rocks also occur along the north-west Scottish coast. All are crystalline, representing both sedimentary and igneous types which have been metamorphosed.

Resting on top of the Lewisian are patches of Proterozoic rocks, which once formed a continuous sheet of unaltered sediments covering and burying the Lewisian. These Scottish Proterozoic rocks are called Torridonian,

SOME OF THE WORLD'S OLDEST ROCKS, as seen in Scotland. Often these Precambrian rocks are much contorted by earth movements which took place in Precambrian times. Without fossils for guidance it is difficult to trace the rock sequences, or the history of these ancient eras.

Photo, Geological Survey and Museum

ANCIENT SEDIMENTARY ROCK. Sea cliff of inclined Torridon sandstone at Cailleach Head, Ross. This rock is composed of sand and pebbles, rounded and faceted by the action of ancient desert winds.
Photo, Geological Survey and Museum

because they are well displayed in the Torridon mountains. They are of continental and shallow water origin, representing scree deposits, desert sands, and shallow water silts, now conglomerates, sandstones, and marls.

The Lewisian rock-surface on which they rest is very irregular, and it seems that the Torridonian sediments buried a quite rugged landscape which had been carved on the Lewisian rocks in Precambrian times. Torridonian rocks are not quite so resistant to weathering and stream action as are the crystalline Lewisian ones below, and so the weather of the last few million years has been stripping the Torridonian from the harder Lewisian beneath. Thus one may see, exhumed from its long burial, the oldest landscape in Europe, a landscape formed on Lewisian rocks in Precambrian times—perhaps 800 million years ago.

In some parts of the world Precambrian rocks are found at the surface over very large areas. These areas are usually lowlands or low plateaux, and they bear only thin patches of later sediments here and there. A study of their geological history shows that these areas have behaved with great stability since Precambrian times. Never, since the beginning of the Cambrian, have they been strongly deformed by earth movements, for the thin patches of later rocks found on them are usually in undisturbed horizontal layers.

Precambrian Shields

Nor have they been strongly uplifted to form mountains, nor long depressed below sea-level to act as areas of accumulation of thick piles of sediments. These large stable regions of Precambrian rocks are called *shields*. Precambrian shields occur in Canada, in Finland and adjoining areas, in north-east Siberia, in west Australia, in central South America, in Africa, and in the peninsula of India.

Many of these areas are of great importance to man, for their Precambrian rocks contain an immense treasury of useful mineral deposits. From the rocks of the Canadian shield (Lake Superior district) come about 85 per cent. of the iron produced annually in the U.S.A. Seventy per cent. of the world's nickel is obtained from Precambrian shield rocks at Sudbury, Ontario. Most of the world's diamonds come from the African Precambrian shield. Copper, gold, cobalt, silver, and radioactive minerals are but a few of the long list of the natural resources locked up in the world's oldest rocks.

LESSON 7

Rocks and Fossils of the Cambrian Period

We now come to the Palaeozoic era, which, being the first to reveal precise evidence of numerous living organisms in the form of definite fossils, is also known as the Primary. The Palaeozoic or Ancient Life era is divided into six periods : Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian.

It must be remembered that these eras and the periods into which they are divided are more or less artificial divisions of a continuous but changing record ; and though the existing strata which are the visible evidence of the periods are not always continuous, they follow a regular sequence.

The various beds of rock composing the strata of the Cambrian period (so called because the beds were first recognized to be fully developed in Wales—Cambria) follow those of the Precambrian era. They are divided into the *Lower Cambrian*, *Middle Cambrian*, and *Upper Cambrian*. In Wales the *Lower Cambrian* is represented by the Caerfai beds of the St. David's area, among the oldest fossiliferous rocks in Britain, and by the Lower Harlech

beds in North Wales. The *Middle Cambrian* is represented by the Solva or Menevian group and the Upper Harlech beds. The *Upper Cambrian* comprises 6,000 feet of Lingula Flags, including bluish and black slates and sandstones, together with 1,200 feet of the Tremadoc group of dark-grey slates. These strata have been estimated to attain a thickness of 20,000 feet.

Distribution of Cambrian Strata

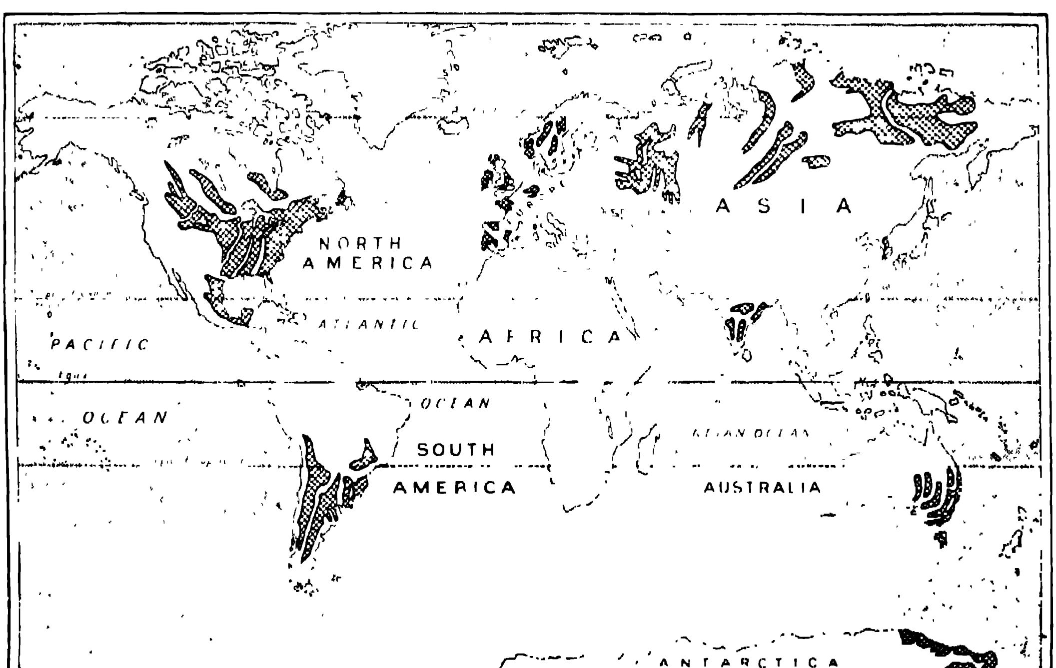
In England the Cambrian strata comes to the surface only in small areas near Nuneaton in Warwickshire, the Wrekin area of Shropshire, the Malvern hills, the Lickey hills in north Worcestershire, and the Lake District, where the beds are present as dark-coloured slates round Skiddaw and the Derwent and Crummock Waters. The greater part of the Isle of Man is covered with the famous Manx slates, together with the grits, shales, and flagstones of the Cambrian period. Also in the Irish counties of Dublin, Wicklow, and Wexford, Cambrian beds similar to those of the Manx slates exist.

In Scotland the beds of the Cambrian period come to the surface only in the extreme north-west, where they overlie the Torridonian sandstone of the Precambrian era. They attain a thickness of about 2,000 feet, and are represented by fossiliferous limestone, Serpulite grit, quartzite, and a thin bed of conglomerate. These beds indicate the very varied conditions which prevailed in the seas on whose floors they were laid down during each epoch of the long Cambrian period.

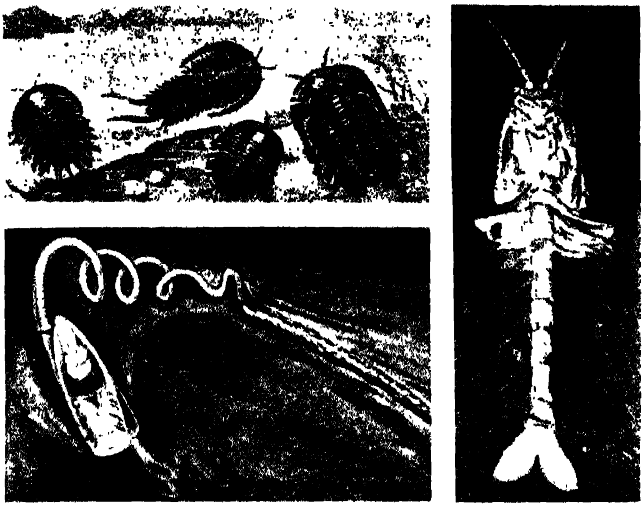
Diverse Materials

On the European continent the Cambrian strata are present in Brittany, in the Ardennes district of Belgium, in Leon, Asturias, Galicia, Seville, and generally over the western districts of Spain and Portugal. In Norway, Sweden, and northern Russia the Cambrian strata are presented as broad, flat deposits apparently but little altered by earth movements since they were laid down. Throughout south-east Canada and in the U.S.A. east of the Alleghanies the Cambrian strata are extensively displayed, having a thickness of from 2,000 to 10,000 feet and lying remarkably flat and undisturbed, as in northern Europe, over the vast Precambrian beds. The Cambrian rocks crop out from under the Andes, in Argentina ; they appear in places as far apart as Korea, India, south-east Australia, Tasmania, and even South Victoria Land in Antarctica. Throughout all these areas the rocks are just as varied as in Britain, consisting of shales, slates, hard sandstones, greywackes, grits, quartzite, quartz-schist, mica-schist, and limestone.

How do geologists know that all these strata, composed of such diverse material, were



CAMBRIAN STRATA. Areas where rocks of this period are found throughout the world.



LIFE IN THE CAMBRIAN PERIOD. In Cambrian mudbanks there lived innumerable shellfish like the brachiopods shown on the right, and lower left. These are (right), a crustacean, and a two-valved creature, Lingula pyramidata. At the top left is a reconstruction of trilobites (now extinct) which were related to crabs and were the most characteristic of the Cambrian fauna.

deposited in the Cambrian period ? The answer is that they can tell partly by the position of the beds relative to those above and those below ; chiefly, however, by the type of fossil.

In the Precambrian era few remains of animal and plant life exist. Not until one comes to the lowest Cambrian beds can one find preserved numerous relics of individual forms of life. Trilobites existed in such profusion that different species of them have been used to designate the Cambrian divisions, e.g. the Lower Cambrian is also known as the Olenellus, for in the beds comprising it the *Olenellus* trilobite has been found in large numbers. In the period when the beds of the Middle Cambrian were being deposited, the trilobite *Paradoxides* became paramount, reaching in some species a length of two feet. The Upper Cambrian has *Olenus* as a distinguishing fossil. These creatures, of which the nearest living representative is the king crab, attained such a degree of development during the Cambrian period that it is often called the age of trilobites.

Low Life Plentiful

Though plant remains are scarce as individual fossils, the lower forms of animal life were plentiful. Brachiopods in particular, both hingeless forms and the horny *Lingula*, were so numerous that the name Lingula Flags has been given to beds which contain them. This genus—the oldest representative of the lamp-shells or brachiopods—still lives in modern seas. Brachiopods became more and more numerous as the Middle and Upper Cambrian times progressed. The univalve gastropods had appeared in the Upper Cambrian and also cephalopods, orthoceras, and nautilus, allied to the cuttlefishes, squids, and paper nautilus of the present time.

The Echinodermata are represented by the primitive Cystidians. These flourished from the Lower Cambrian times until the Carboniferous, when they became extinct. The Medusae or jelly-fishes were present in the Middle Cambrian times ; and the annelids, the soft-bodied sea-worms which were present in the Precambrian era, must have been plentiful in Cambrian times, judging by the surviving traces of their burrows and trails. Hydrozoa are represented by a variety of graptolites of the dendroid form in the Upper Cambrian, and there are many remains of early types of sponge. Radiolarians and other forms of protozoa are in evidence.

LESSON 8

Ordovician Rocks and Fossils

The rocks of the Ordovician period are named after an ancient British tribe, the Ordovices, who inhabited that part of Wales and the Border, now approximately the counties of Merioneth, Montgomery, and part of Shropshire, in which the rocks were found by the pioneer geologists to be distinctively developed. An English geologist, Charles Lapworth, coined the name in 1879, and since then it has been adopted for rocks of this particular period.

The Ordovician strata reach a great thickness in some parts—15,000 feet in Galway and Mayo, 12,000 feet in the Lake District. They lie immediately above the Cambrian, of which they were at one time considered to form a part. The Ordovician period, in fact, was a continuation of the Cambrian, in which similar conditions prevailed, but evolution had produced new forms of some of the types of animals found as fossils in the Cambrian rocks, such as new forms of trilobites ; and new types of animals appear in Ordovician rocks, such as corals, starfish, and backboned animals.

Ordovician rocks are composed of various grits, sandstones, conglomerates, quartzites,

greywackes, shales, or limestones ; like those of the Cambrian, these were deposited on the floor of shallow seas. Ordovician seas covered Wales, the Lake District, southern Scotland, and extended into Ireland and Scandinavia.

Notable Outcrops

The Ordovician rocks are divided into four distinct series : *Upper Ordovician* or Bala, known as Ashgillian and Caradocian ; *Middle Ordovician* or Llandeilo, known as Llandeilian, Llanvirn, or Llanvirnian ; and *Lower Ordovician* or Arenig, known as Arenician. They are so called after the districts in Wales in which the particular series is exceeding well developed. Since then the rocks of this period have been identified in much greater deposits in other parts of the world.

The Ordovician beds come to the surface and cover a large area in Wales, including the greater part of Caernarvonshire, a large district in Montgomery and Merioneth, the whole of Cardigan, most of Carmarthen, and the immediately adjoining districts of Radnor and Pembrokeshire.

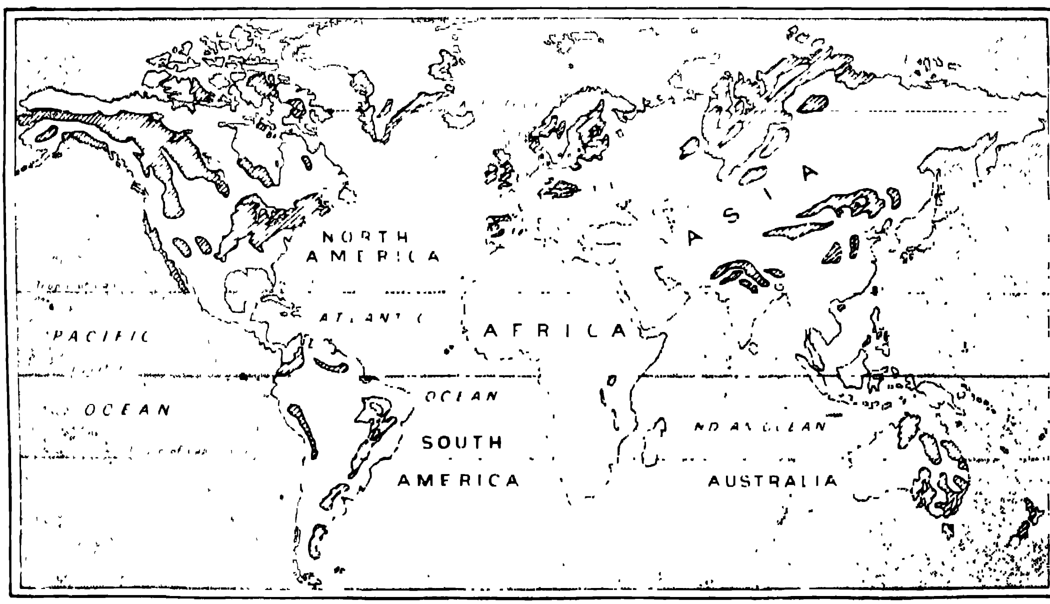
In England they are not much in evidence at the surface except in south Shropshire, where they constitute a continuation of the Montgomery strata and attain a thickness of 10,000 feet. They are found on the western side of the Long Mynd and on the eastern side in the Caradoc area. In Cumberland they compose all the mountainous region north-west of Ambleside and Coniston Water and, extending to Wastwater, combine with volcanic material to compose the grand mountainous masses of Scafell and the surrounding peaks. The Skiddaw slates and the whole area extending north, east, and west of Keswick to beyond Crummock Water are Ordovician. In the Lizard district of Cornwall and in south Devon contorted sedimentary rocks of Ordovician age are plentiful.

In Scotland the Ordovician rocks exist chiefly in the southern uplands, extending in a belt from northern Wigtownshire to the Lammermuir hills. This belt extends across to Ireland, where it forms a succession of outcrops, attaining a grand development in Mayo and Galway. An obvious extension of the Welsh series spreads over Wexford, Waterford, Wicklow, and Kildare. Brittany and Normandy also have outcrops of these Ordovician rocks.

Wide Distribution

The north coast of Spain and other areas of the Iberian peninsula present Ordovician rocks of very similar description, attaining to a thickness of about 1,800 feet. In Bohemia it is estimated that they are about 3,000 feet thick. In the Baltic countries, in Latvia and Finland and throughout Scandinavia, they are extensively present, chiefly in the form of limestone which reaches a thickness of only about 300 feet.

In North America the Ordovician period is represented by strata containing fossils of trilobites, identical with those found in the British series , this suggests that Ireland and



ORDOVICIAN PERIOD. The world distribution of rocks of this period is indicated by shading.

as it were, the successive divisions of Ordovician time.

Trilobites were also very plentiful, and, as in the case of the Cambrian period, particular species are identified with the strata of certain epochs. Most noteworthy are the trilobite *Illaenus* of the Bala series ; *Ogygia buchi*, *Asaphus tyrannus*, and *Agnostus* of the Llandeilian series *Phacops* in the Llanvirnian series *Trinucleus*, which had no eyes, in the Caradocian series, and *Ogygia Selwyni* in the Arenician series. These types were all very distinctive and of wide distribution.

VOLCANIC ROCKS in Cumberland and Wales. In Britain the Ordovician period was one of great volcanic activity. Mountain masses composed of rocks combined with volcanic material include Scafell Pike (above) in Cumberland ; this is the highest point in England. Snowdon (right), in Caernarvonshire, is mostly volcanic lava and ash of the same period.

Scotland were linked up in Ordovician times with a shore line across which is now the Atlantic. Ordovician rocks occur over large areas of eastern Canada, the U.S.A., and British Columbia. They are present, too, in many regions of South America, in the south-eastern area of Australia, in Tasmania and New Zealand, in the northern Himalayas, northern China, Siberia, and the south of Greenland.

Graptolite Fossils

Throughout these wide areas the identity of each series of Ordovician rocks can be established by means of the fossils present. The most distinctive of these are the graptolites. These have generally been preserved as films of carbonaceous material resembling pencil-writing or drawing (hence their name) ; others are preserved " in the round," and were marine creatures, each encased in a small horny " cell " or cup, the cups being strung together on horny filaments. The graptolite thus represents a colony or assemblage of individuals arranged, some species on one side of a single stem, some species on both sides. There were a great many varieties ; some were curved, as the *Didymograptus* of the Llanvirnian series ; others had many-branched forms, as the *Tetragraptus* of the Arenician series. The *Phyllograptus*, also of the Arenician series, had leaf-like forms. The *Climacograptus*, of the Llandeilo and Bala series, was straight. Thus many distinct species of graptolites date,

The brachiopods *Orthis* and *Strophomena* were plentiful in the arenaceous deposits, and corals and crinoids (sea-lilies) were abundant in the limestones ; most plentiful were the now extinct Cystidians, 23 species having been found in the Bala series alone. Lamellibranchs were well represented by *Palaearca* and *Redonia* from the Arenician to the Bala series, together with numerous species of gastropods, and the cephalopod *Orthoceras*.

The most impressive find among all the fossil fauna of these times has been the discovery in the Ordovician strata of Colorado of numerous fragments of fish-like creatures possessing a backbone—the ostracoderms. They have not been found in Europe, and, so far is as known, they are the earliest of all vertebrates.

Ordovician Flora

As regards the Ordovician flora, no individual fossils of terrestrial plants have, so far, been found, but a seam of anthracite at Olonets in Finland suggests the existence of a prolific vegetation in favoured areas during this period.

In Britain the Ordovician age was one of great volcanic activity ; in Caernarvon, Merioneth, and Montgomery the mountain ranges of the Arenigs, the great masses of Plynlymmon,

Cader Idris, and, greatest of all, Snowdon, are the denuded remains of this volcanic area. In Cumberland, throughout the Borrowdale district, including the peaks of Scafell and Helvellyn, are masses of volcanic ash and lava which have been calculated to reach a thickness of 10,000 feet.

In Ireland volcanoes were active in the Dublin and Waterford areas. In Scotland the region of volcanic activity was restricted to the southern uplands, more particularly the Girvan and Ballantrae areas of Ayrshire. Between this district and the Lammermuir hills in the east there was much folding of the strata and outpourings of lava and ash. The lava on reaching the sea produced pillow-lavas as a consequence of the sudden chilling. The sheets of volcanic ash and lava are sandwiched between the various beds of the Ordovician series ; so that it is possible in many instances to tell whether the volcanoes were active in, say, early Arenician or the very much later Llandeilian or still later Ashgillian times.

The Ordovician rocks provide the following commercial products : silver, zinc, lead, barytes, graphite, road-metal, flagstones, slates, and quartzite for the manufacture of glass. Thus man finds many uses for the materials that came into existence between 420 and 350 million years before his own advent.

LESSON 9

Strata and Fauna of the Silurian Period

The rocks representing the Silurian period were so named by Sir Roderick Murchison (1792 1871) because the large area in central and south Wales where they are particularly prominent was once occupied by the ancient British tribe of the Silures. In addition to Radnor, Montgomery, and Denbighshire in Wales, the Silurian rocks are found at the surface in England in south Shropshire, in the Malvern hills of Worcestershire, in Herefordshire, in the Usk district of Monmouth, and over a large area of south Cumberland and Westmorland, enclosing both Windermere and Coniston.

CORAL IN ENGLAND. Indicative of the tropical conditions of millions of years ago is the coralline limestone found in various parts of England. The fossil coral shown above is from Wenlock Edge, Shropshire.
British Museum, Natural History

In Scotland the Silurian rocks appear only in the extreme south, where they constitute a broad belt some 30 miles wide, extending from the rocky coasts of Berwickshire, through Selkirk, Dumfries, Kirkcudbright, and southern Wigtownshire, to the Mull of Galloway. Connecting beneath the sea, the Silurian rocks again form an extensive area in the Irish counties of Down, Armagh, Louth, Monaghan, and Cavan, reappearing in small outcrops in Mayo, Galway, Clare, Tipperary, Limerick, Kerry, and Waterford.

The Silurian strata are extensively developed in Scandinavia, particularly in the region of the island of Gotland ; for this reason the Silurian system is frequently referred to as "Gotlandian." Throughout Finland and in northern Russia it forms a belt extending to the Urals. In Poland, Bohemia, Germany, northern France, the Pyrenees, and Portugal, the Silurian rocks are found, though of no great thickness usually under 1,000 feet ; but in Scandinavia they reach 4,000 feet.

The Silurian rocks cover large areas in India, Burma, and western China ; they also appear extensively in south-east Australia and New Zealand. In America they are present in the Appalachian Mountains, and in Pennsylvania, Ohio, Michigan, Illinois, Indiana, and throughout Ontario and the area north of the Great Lakes, even to Hudson's Bay and Greenland ; in the south they stretch from Brazil to Peru. Throughout all these areas the Silurian rocks are almost entirely composed of either sandstones, limestones, or shales, while there is an almost complete absence of volcanic material of the period. From this can be inferred a cessation from the volcanic upheavals which were so characteristic of the preceding Ordovician times.

The Silurian period is divided into three successive series of strata, each representing an epoch. The uppermost and therefore most recent is noted first :

Ludlovian Series—represented by .. .. (up to 5,000 feet thick)	Upper Ludlow Beds Aymestry Limestone Lower Ludlow Shale
Salopian or Wenlockian Series —represented by .. .. (up to 3,000 feet thick)	Wenlock Limestone Wenlock Shale Woolhope Limestone
Valentian or Llandovery Series —represented by .. (up to 10,000 feet thick)	Tarannon Shale Upper Llandovery Lower Llandovery

These thicknesses of strata apply solely to the above districts, whence they derive their names. In the Lake District the whole series attains a thickness of about 13,000 feet, and in Scotland 6,800 feet.

Borings indicate that the system lies beneath the superimposed strata of most of England, and extends south-eastward into France beneath the Channel. There these rocks stretch from Brittany to the Ardennes. Westward, they lie beneath most of the superimposed beds of Ireland. In all these areas the Silurian rocks represent marine sediments. In Britain they are often richly fossiliferous. The Wenlock limestone contains small reefs, which can be seen at Wenlock Edge and near Dudley, both these places providing rich collections of fossils.

The identification of the beds of each series is assured by the presence of certain forms of fossilised life. In the Silurian, very different species and types have appeared, though the trilobites and graptolites still remain very similar to those of the preceding Ordovician period. These are still the dominant and most prolific fossils, but the graptolites now show the cells on one side of the stem only and are known collectively as the Monograptidae.

Great Crawling Creatures

The trilobites show a decided decline both in numbers and development ; though *Phacops*, *Illaenus*, and *Homalonotus* still abound, many Ordovician types have completely disappeared. Eurypterid species, in late Silurian times, attained gigantic dimensions ; the scorpions are their nearest modern descendants. *Pterygotus* was the largest crustacean known ever to exist, reaching a length of six feet ; *Eurypterus* attained 18 inches. These great creatures crawled about in the shallow and muddy sea beds where, close to the shore, they probably spread havoc with their powerful claws among the relatively defenceless trilobites.

LIVING GARDENS IN SILURIAN SEAS. During the Silurian period sea lilies—not plants, but animals allied to starfish—grew in dense groves which in the course of ages have been compressed into beds of limestone. At the top is a fossil sea-lily ; lower, a reconstruction after Mr. Charles R. Knight. *British Museum*

The " Bone Bed "

The first appearance of fossil fishes in the beds of this country is found in the Ludlow series, in what is known as the " Bone Bed," which is full of the fragmentary remains of fishes and Eurypterids. These fish-like creatures are the ostracoderms, primitive jawless forms which had appeared in the Ordovician rocks of Colorado. The head and forepart of the ostracoderms were protected by hard bony plates, and while there were no limbs or paired fins, dorsal and caudal fins had appeared. Most important of all were the beginnings of the vertebral column; although this was probably not composed of bone but of cartilage, it served as a support for the muscular tissue of a powerful body and tail.

Some of the echinoderms attained their maximum development during the Silurian Period, both crinoids and cystideans contributing their remains to the many massive beds of limestone. Corals, increasing in abundance, thus helped to build limestone.

At the end of Silurian times deposition ceased in these ancient seas, which covered a large part of Britain. Then earth movements broke off the history of deposition, folded the marine sediments

formed in the three Lower Palaeozoic periods, and heaved up the newly folded rocks to form a land-mass diversified with mountains, valleys, and rivers with their flood plains and estuaries. In Britain the folding was most severe and complex in Scotland, hence the name Caledonian is given to this episode of earth movements; in Wales gentler and broader folds were formed, and in the Midlands the rocks were relatively little disturbed. The new geography created by the upheaval of these folded Lower Palaeozoic rocks set the scene for the next period of geological history, which is called the Devonian.

LESSON 10

Devonian and Old Red Sandstone

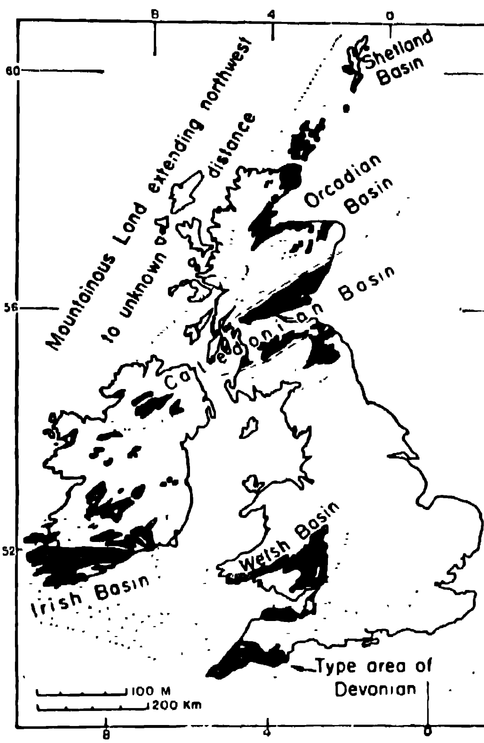
The series of marine strata representing the Devonian period was so named by two geologists, Adam Sedgwick (1785-1873) and Sir Roderick Murchison (1792–1871), in 1839, because of the distinctive fossils discovered in Devon and Cornwall. Marine sediments of this age have also been found in west Somerset and in borings beneath London. In Britain, north of a line running from the Bristol Channel through London, the same period of geological time is represented by strata called the Old Red Sandstone, with distinctive types of both rocks and fossils having little in common with the marine series.

That these series existed contemporaneously is proved from the facts that they both overlie the Silurian, and both are immediately below the Carboniferous, but neither the Old Red Sandstone nor the Devonion overlies the other to any extent; indeed, in west Somerset the two types of rock are found to be interleaved one with the other. The stratigraphical evidence thus indicates that they were deposited under different conditions during the same period, generally called the *Devonian System*. The Old Red Sandstone series of rocks were formed under continental conditions, as the deposits of lake floors, fans of torrent debris, or blown sands in regions suffering periodic spells of aridity.

Advance and Recession of the Sea

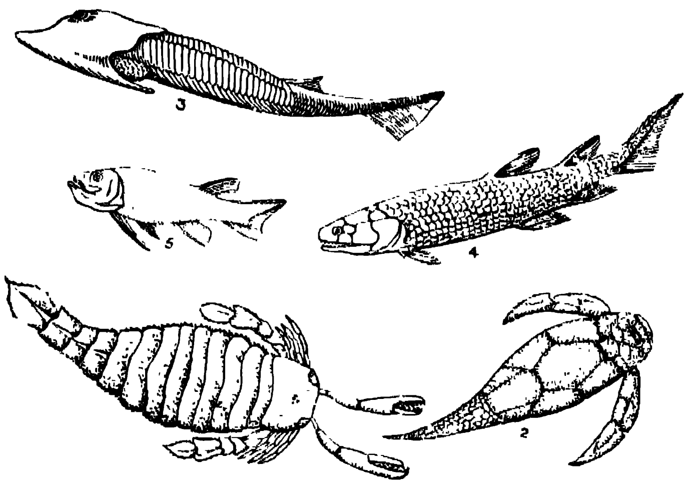
Britain is not the only country possessing Devonian age rocks of these two contrasting kinds, the marine and the continental. Both types are found, for example, in North America and in Europe, and in both these regions there is an intermediate zone where the two types are interleaved. By mapping the distribution of these types of rock, it is possible to construct a map showing the main outline of the geography of the period, as has been done for Europe. In the zone of interleaving, the marine rocks represent an advance of the sea, the continental ones mark the recession of marine water. This zone was evidently one of shifting coastlines throughout Devonian times.

The marine Devonian series found at the surface in Devon and in Cornwall are disturbed and contorted by the earth movements which took place at the end of the Carboniferous period. Yet a study of these rocks suggests what conditions were like in this part of the Devonian seas. Beds of Lower Devonian rocks run in an east-west band from Newquay to Dartmouth and Torquay. They represent dark muds, often with limey bands, and sands, now



DEVONIAN FORMATIONS in the British Isles are shown black in this map. The stippled area represents the probable extent of marine and brackish water in Devonian times. The other areas, outlined by dotted lines, were mountain-girt basins in which the continental deposits of Devonian age, the Old Red Sandstone, were formed. The dashed lines are two important Scottish faults, the Highland boundary fault in the north, and the southern upland fault to the south.

From "Historical Geology," by C. O. Dunbar (Wiley and Sons, New York)



THE AGE OF FISH. Following the Silurian period true fish became abundant in the Devonian and Old Red Sandstone periods, predominating over other forms of life. Devonian examples shown here are Pterichthys (2) and Cephalaspis (3), both armoured. Developments of the Old Red Sandstone are Pterygotus (1), a giant lobster or scorpion 6 ft. long, Osteolepis (4), Acanthodes (5).

compacted to slates and hard quartzites. They contain brachiopods, gastropods, corals, and trilobites, animals which lived on the muddy or limey floor of those rather shallow seas.

The Middle Devonian rocks occurring just north of the Lower Devonian outcrops, can be studied on the coast at Torquay and inland to the west. Most prominent, as forming steep cliffs on the coast and in large quarries inland, are thick limestones representing reefs built up in clear shallow waters. The remains of the reef-building animals—moss-animals or bryozoa, and corals—are abundant, and various other reef-dwellers, brachiopods and nautiloids, are also present.

The Delabole " Butterfly "

To the west, in Cornwall, the reef-limestones die out and are replaced by muds, now compacted into grey slates. These represent a different, though still shallow-water, environment, with different marine animal remains—those which preferred a mud floor and muddier waters to the clear water and peculiar conditions of the reefs. Near Newton Abbot volcanic ashes and lavas are interbedded with, or largely replace, the limestone reef rocks. Evidence of volcanic activity continues in Upper Devonian rocks and at Pentire Point, near Padstow, is a cliff nearly 300 feet high composed of lavas whose " pillow " structure shows that they were erupted beneath the sea. The Upper Devonian slates of the quarries at Delabole in north Cornwall contain a well-known fossil, sold to visitors as the Delabole " butterfly." It is really a brachiopod, whose ridged shell has been distorted by the compression and shearing which these rocks suffered in the earth-movements at the end of Carboniferous times.

Early Ammonoids

The marine fauna of the Devonian period, while generally similar to that of the Silurian, had certain marked differences. The graptolites had died out except for the dendroid forms. The trilobites were still fairly abundant but had passed the peak of their evolutionary development, being less numerous and less varied compared with Lower Palaeozoic times. It is in the limestones and shales, not the sandstones, that the fossils are numerous in south-west England. In North America, sandy marine Devonian rocks are often crowded with brachiopod shells, and a glass sponge, its lacy skeleton made of great numbers of needles of silica; starfish are sometimes found—one specimen had died in the act of devouring a bivalve.

The cephalopods had increased both in genera and species ; one order of them, the Ammonoidea, which is now extinct, made its appearance. Early forms of the ammonoids have the typical closely coiled shells and, as in many other cephalopods, the shell is divided into a number of separate chambers by partitions. The edge of the partition wall can be seen as a line or suture on the surface of the shell. These early ammonoids are called goniatites (Greek *gonia*, an angle), because the crimping of the partition walls produced an angular suture line. Goniatites are usually found in muds laid down in rather deeper waters. The brachiopods were common.

The best areas for the study of these Devonian rocks and fossils are the coastline from Minehead to Ilfracombe, Combe Martin, and, where exposed, on Exmoor ; also Pilton, Chudleigh, Newton Abbot, Torquay ; from Dartmouth to Plymouth and Polperro, Launceston, and the north coast of Cornwall to St. Ives ; and from Penzance eastward along the coast.

Accumulation Areas

To the north of the seas covering southern England lay the continent which emerged after the Caledonian earth movements at the end of Silurian times. Crossing the continent from N.E. to S.W. were a series of mountain chains, ridges, and hills, which divided it into a number of hill-girt natural basins. These basins acted as accumulation areas for the

deposits of the period, and the fact that these deposits are often red and sandy gives the formation its name, Old Red Sandstone.

The Welsh basin contains the delta deposits of a great river system, sometimes forming a delta plain, sometimes flooded to form a series of shallow lagoons. The silts, sands, and pebbles of this great delta can now be seen as green, brown, or red sandstones, marl and conglomerates, out of which such hills as the Brecon Beacons have been carved by the erosion of much later times.

Conditions in the Scottish part of the Devonian continent are well seen by studying the rocks of the Midland Valley, in which Glasgow and Edinburgh are situated. The Midland Valley is defined geologically by two great parallel faults, the Highland Boundary fault to the north and the Southern Upland fault to the south. Movement along these faults had begun in Devonian times, and let down the great block of country between them so that it formed a rift valley—the Caledonian Basin. Piled against the sides of this valley are huge spreads of Lower Devonian torrent deposits, up to 15,000 feet thick in some places, their pebbles, sand, and boulders well rounded, which were thrown down pell-mell without much sorting.

The fragments were derived from the bordering mountains to the north and south of the valley, and they bear witness to the torrential rains trapped by the newly erected peaks of the mountain ranges. Lenses of sand and shale were laid down in lakes and pools along the valley bottom, and volcanoes poured out lava flows and spreads of ash. The lavas, more resistant to weathering processes than the other Old Red Sandstone sediments, now form the Ochil, Sidlaw, and Pentland hills in the present Midland Valley.

Flagstones

The life of the Caledonian basin in Lower Old Red Sandstone times probably clustered round the pools and lakes, for in the sand and shale lenses are found abundant fragments of primitive leafless or needle-leaved land plants. There are also eurypterids—jointed limbed invertebrates related to the scorpions, millipedes, and primitive fishes—creatures which had not acquired jaws, such as the genus *Cephalaspis*, and early jawed forms such as acanthodians.

Middle Devonian age Old Red Sandstone does not occur in the Midland Valley of Scotland, or indeed anywhere in Britain except in the Orcadian basin, where it represents the bottom deposits of a large lake. These now form the jointed flagstones which characterise part of the coast of Caithness. They make excellent paving stones.

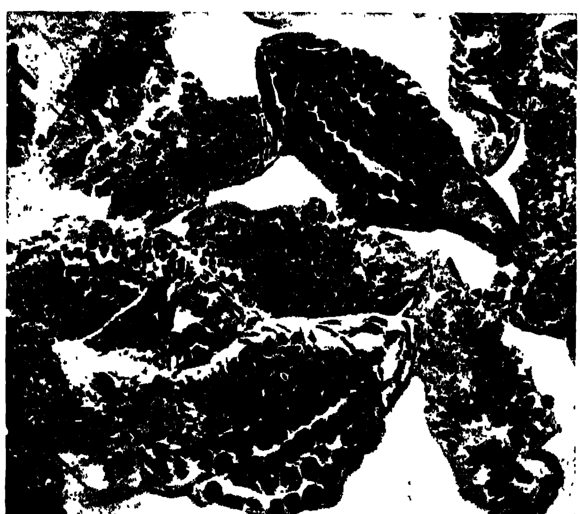
A good fish fauna is found in certain layers, and amongst them is the earliest known ancestor of those fish which are the common inhabitants of to-day's fresh and sea waters—the ray-finned actinopterygians. Lungfish are also found, ancestors of the modern forms, and osteolepids, which also had lungs, and which gave rise to the coelacanths and to the first four-footed animals by the end of Devonian times.

One small pocket of Middle Old Red Sandstone rocks, found in the Grampian mountains, contains a band of chert which seems to be a petrified peat. The plant remains are beautifully preserved in silica deposited from the waters of a warm spring, and in the peat occurs the earliest known insect, a primitive wingless springtail.

In Ancient Valley Pools

Deposition was resumed in all the basins of the Old Red Sandstone continent in Upper Devonian times. Pool and lake deposits have plant remains with well developed leaf fronds, resembling those of the Carboniferous age forests. The fishes are of similar types to those inhabiting the Orcadian lake. But there are signs of an increasing periodic aridity in these ancient valley pools. Often their muds dried out and cracked under the sun's heat, the mud-cracks being buried and preserved by the sediment which was washed in at the next rains.

Fish crowded together in shrinking pools and were buried by windblown sands. Modern



HOW DEVONIAN FISH DIED. In the Devonian period desert conditions spread, lakes and rivers dried up, and fish from large areas were crowded into pools, where they died when the water finally disappeared. The geologist finds them packed close, as in this fossil from an Old Red Sandstone stratum.

British Museum, Natural History

lungfish can survive drought for a while by burying themselves in the damp mud at the bottom of a drying pool, and breathing air with their lungs. No doubt the Upper Devonian lungfish did the same. But to go overland in search of a well-filled pool was evidently also an advantage, for the first four-footed animal has been found in late Devonian rocks. It was found, not in Scottish Old Red Sandstone rocks, but from similar deposits in Greenland, and has five-toed limbs for land-walking and a fish-like tail for swimming. This early four-footed animal is one of the most primitive members of the Amphibia, most of whom spent part of the time on water and part on land, and most of them have to return to water to breed. Modern amphibians are frogs, toads, newts, and salamanders.

By the end of the Devonian period the Old Red Sandstone continent had been planed down by 30 million years of weathering and erosion. Subsequently much of this land began to sink and the sea encroached ; the great beds of limestone began to be formed which now comprise the Carboniferous limestone constituting the base of this great age of plants. Many Devonian rocks have economic value. Old Red Sandstones and limestones furnish building material ; roofing slates come from Devon and Cornwall ; and road-metal from granites.

LESSON 11

Deposits of the Carboniferous Sea

The Carboniferous period covers about 50 million years of the earth's history. Although the name comes from *carbonem*, Latin for coal, and was given because of the numerous coal beds laid down during the period, these form but a small proportion of the whole system, which, comprising limestones, shales, sandstones, and bands of ironstone, attains a thickness in many areas of 20,000 feet.

The character, or *facies*, of these rocks shows that the Carboniferous period is represented by a marine and a terrestrial series of beds, together with estuarine and fresh-water types. There are also intercalated layers of volcanic material which bear witness to successive eruptions in certain areas.

Limestone and Coal

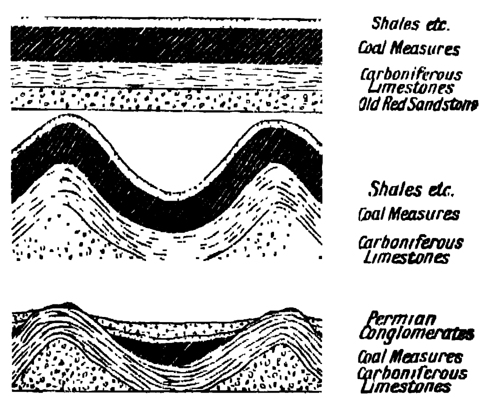
The whole has been divided into *Lower Carboniferous* and *Upper Carboniferous*, with further subdivision into Lower Carboniferous limestones and Yoredale beds, Upper Carboniferous Millstone Grit beds and Coal Measures. The lowest beds of the entire series are the lower limestone shales, which also contain layers of sandstone and Carboniferous slate. Above these are the great beds of Carboniferous limestone, which are, of course, marine, and are composed largely of corals, crinoids, and foraminifera. These beds are overlaid by the upper limestone shales—generally known as the Yoredale beds—which contain bands of radiolarian chert, and are also marine.

The next series is the Millstone Grit beds, composed of hard siliceous rocks with bands of shale, sandstones, and flagstones. Occasional seams of coal indicate the beginning of swamp forest and terrestrial conditions. They form, generally, the foundations of the Coal Measures, and some layers contain remains of terrestrial plants. These beds were apparently deposited in the deltas of rivers, lagoons, and shallow marine waters, representing alternations of marine conditions with, occasionally, those of brackish or fresh-water swamps in which flourished the vegetation more particularly associated with the Carboniferous period.

The fourth and last series, the Coal Measures, consists of sandstones, shales, and clays, with numerous layers or seams of coal together with bands of ironstone. Marine rocks are rare ; most of the rocks represent brackish to fresh-water mudflats and sandbanks periodically colonised by swamp-forest.

The Pennines

The entire Carboniferous system is well developed in Britain, where the beds lie flat in some places. But mostly the one-time continous sheet of strata which lay horizontally



HOW BRITAIN'S COALFIELDS WERE SAVED. When at the end of the Carboniferous period the earth's crust became folded into ridges, most of the coal measures were subsequently lost through denudation and only those preserved that lay in the pockets of the hills. These were covered again later.

CHEDDAR CLIFFS AND GORGE. Carboniferous or mountain limestone composes many English mountains, and it is well exposed in the cliffs at Cheddar, Somerset. The famous gorge in the Mendips was formed by the wearing away of the limestone. Caverns run deep into the hills here, and they contain many stalactites and stalagmites.

over much of England is now divided into synclinal troughs of basins, by subsequent foldings. The chief of these folds are the Pennine, extending north and south, together with the Hercynian system of east-west folds, extending from the west of Ireland through southern England to Westphalia. Thus great and lesser fold-basins or synclines were formed which preserved large areas of coal-bearing strata from denudation in later times.

Sandbanks and Clay Flats

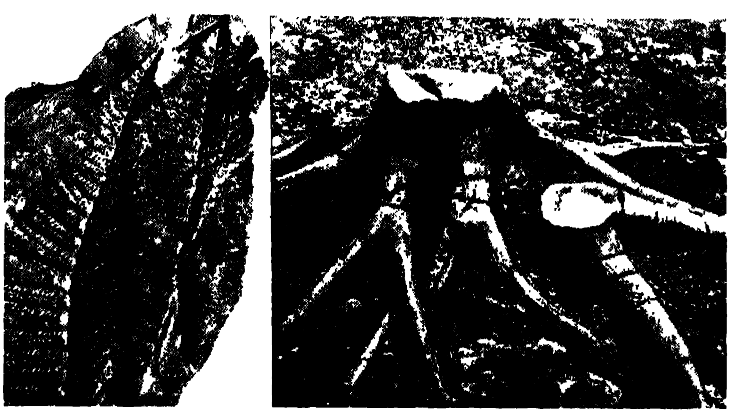
Following the Devonian period came a long era of gradual subsidence over part of Britain and Ireland ; much of the Old Red Sandstone area was submerged, and in the clear shallow waters of the warm sea lime was precipitated as grey mud ; organisms lived and died, their shells and skeletons combining with the lime mud to build up, at the gradually sinking sea-bottom, beds of grey Carboniferous limestone, thousands of feet thick in some places.

The sea submerged the south of England and parts of Yorkshire and Lancashire and Ireland, extending northward round central and west Wales, which was land in Carboniferous times, and from which a peninsula stretched eastwards over what is now the Midlands. It extended to southern Scotland, where coastal deposits of the Lower Carboniferous sea are found in the Midland Valley; sand and clay washed down from a great northern continent formed layers of sandstone and shale. Periodically the sandbanks and clay flats were colonised by swamp vegetation, whose remains provide coal seams of Lower Carboniferous age in this area, in addition to those of Upper Carboniferous age. Sometimes the sandbanks and clay flats were invaded by sea-waters, the shore retreated a little, and limestones were formed.

Much volcanic activity occurred in the Midland Valley of Scotland in Lower Carboniferous times. From the sheets of lava poured out of these volcanoes have been carved (by wind and rain and other natural agencies) the present Kilpatrick and Cathkin hills in the Glasgow district; and the famous Arthur's Seat, 822 ft. high, overlooking Edinburgh is an old, lava-filled, volcanic vent of this age. Close by Arthur's seat are the Salisbury Crags, a crescent-shaped escarpment 60-70 ft. high. Slight volcanic activity occurred in Derbyshire, the Isle of Man, and south-west Ireland at this time.

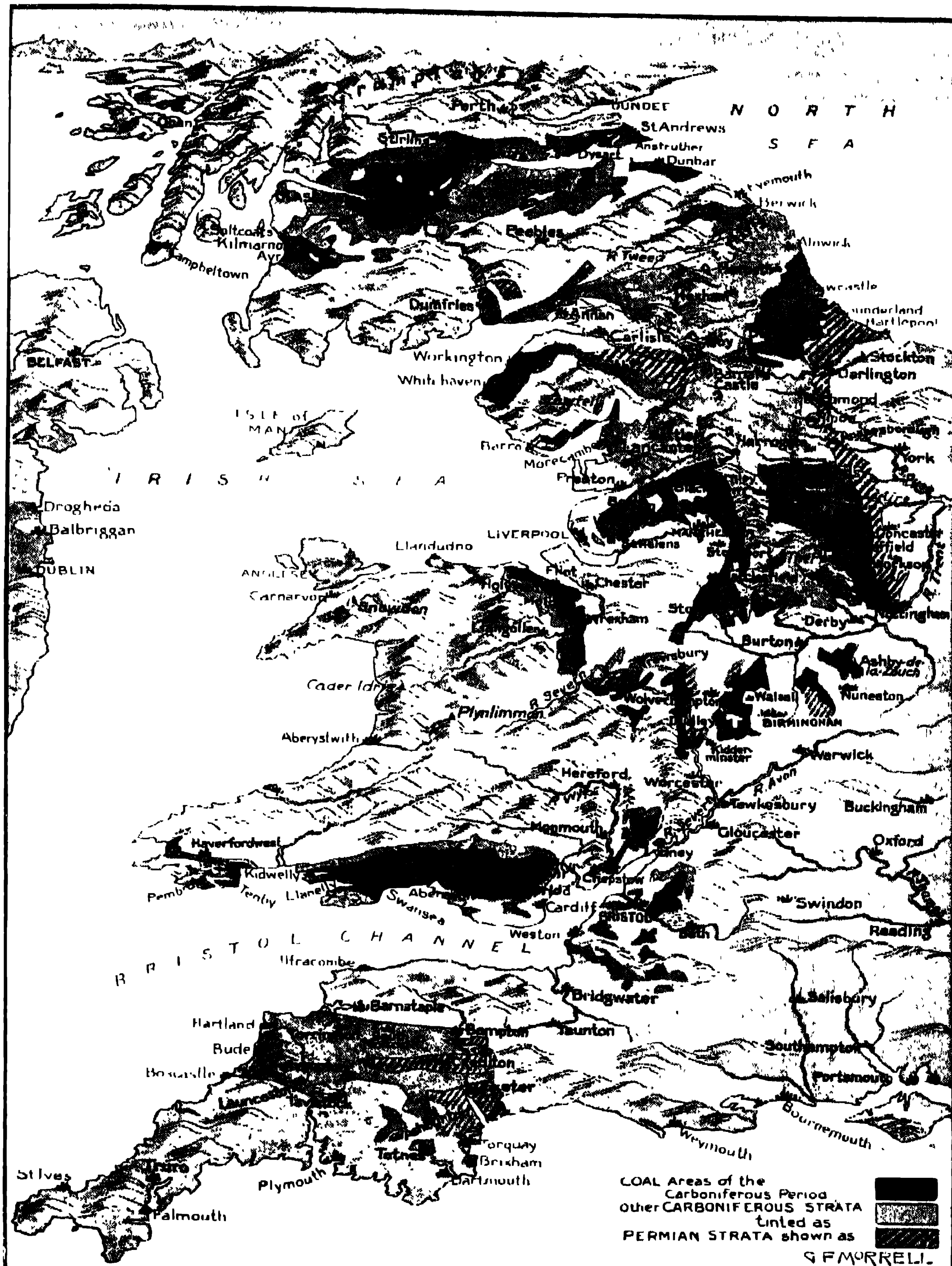
Mountain Limestone

The Carboniferous limestone was originally called " mountain limestone," because it composed so many English mountains, such as the Pennines, the Peak, and the Mendip hills. It can also be seen well exposed in the gorge of the Avon near Bristol, in the Cheddar cliffs, and the crags of Derbyshire. In south Wales the thick beds of this limestone can be observed along the cliffs from the Mumbles to Worm's Head, and



PETRIFIED VEGETATION OF CARBONIFEROUS TIMES. This imprint (left) of a fern that flourished in the Carboniferous period was found in a coal seam near Radstock, Somerset. There is plentiful evidence of the abundant and diverse flora of that period. A large petrified tree, whose base is seen on the right, was discovered standing erect in a seam at Clayton, near Bradford, Yorkshire. See also illus. p. 1878.

Photos, Geological Survey and Museum



CARBONIFEROUS AND PERMIAN STRATA IN BRITAIN

in the St. Gowan's Head district near Tenby Throughout the Pennine area of Yorkshire, Durham, and Westmorland, together with a large part of Northumberland, this "mountain limestone" approaches the surface, and in the Lancashire Pennines it attains the immense thickness of 6,000 feet.

In Scotland it covers a large area of the Lowlands from Ayrshire to Haddington, extending over most of Fife, and it is well displayed at Burntisland and elsewhere along the coast. No trace is found north of the St. Andrews area, from which it appears that here was the farthest extent of this Carboniferous sea. The Carboniferous limestone is most extensively presented in Ireland, where it covers 15,000 square miles and attains a thickness of over 2,000 feet. The lower limestone shales upon which these beds rest are well exposed over a large area of northern Mayo, and in the south of county Cork.

AN IMPRESSION OF A FOREST SWAMP during the chief coal-forming period (Carboniferous), about 250 million years ago. This is a photograph of the diorama exhibited in the Geological Museum, South Kensington, London.

Extent of the Carboniferous Sea

In addition, there are the upper limestone shales, also known as the Yoredale beds. These overlie the "mountain limestone," and are well developed at Yoredale, in Yorkshire; they also cover the Pendleside area in Lancashire, and merge into the Pennine limestone.

These complete the purely marine series of the Lower Carboniferous. The Millstone Grit series and the Coal Measures, constituting the Upper Carboniferous, are considered later.

The great Carboniferous sea, with its thousands of feet of marine deposits, was not peculiar to Britain. These deposits extend across northern France to Belgium, where in the Meuse area they attain a thickness of 2,500 feet. Thence they continue through south Germany and Bohemia to Russia, whence they stretch across Siberia to northern India, China, Japan, and Alaska. In North America they cover an area of about 200,000 square miles. In Australia the Lower Carboniferous attains a thickness of 11,000 feet of shale, sandstones, and limestone.

Fossils of the Lower Carboniferous

The fossil remains in the Lower Carboniferous series are, of course, marine; many resemble Devonian forms. Corals, chiefly rugose types, were abundant; while the crinoids were so numerous that their remains produced beds of limestone hundreds of feet thick, known as crinoidal limestone. The genera chiefly represented are *Platycrinus*, *Actinocrinus*, *Cyathocrinus*, and *Granatocrinus*. Brachiopods were plentifully represented by *Spirifer*, *Productus*, *Pugnax*, and *Chonetes*. Polyzoa were very numerous and foraminifera are abundant in places. Among the cephalopods, goniatites were the most numerous.

Trilobites had greatly declined, being represented by the small *Phillipsia*, *Griffithides*, *Proetus*, and *Brachymetopus*. The trilobites virtually ceased to exist in the Carboniferous period, and the eurypterids greatly declined. The gastropods continued to flourish, *Bellerophon* and *Euomphalus* frequently appearing. Fishes were often numerous, judging by the number of teeth and spines which are found in certain rock-bands, particularly of the shark type; they were of immense size. The shellfish-eating sharks, *Orodus*, *Psammodus*, and *Petalodus*, were the most noteworthy.

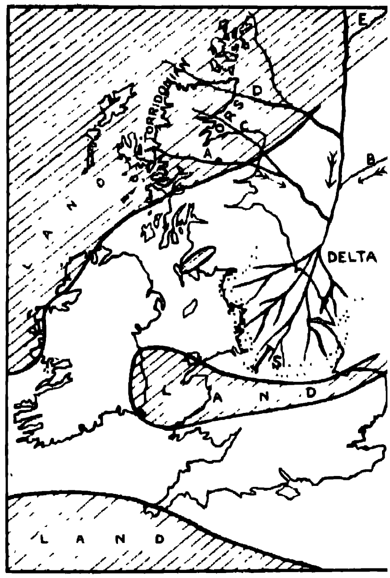
The chief economic products of this series are limestone for building and the production of lime and sandstones for making glass. Oil is distilled from the cannel and oil shales which exist south and west of Glasgow. Iron ores, lead, and zinc occur plentifully in veins and pockets in the limestone.

Deposits of a Great Delta

The lower part of the Upper Carboniferous series of strata represents the deposits of a great river delta, which buried the Lower Carboniferous limestones with its sands, pebbles, and silts. By studying the pebbles of this delta deposit it is possible to make a map of the vast river system which transported them, for many of the pebbles are of older rocks whose characters and place of outcrop are well known. By mapping the distribution and thickness of the deltaic

rocks the delta itself can also be reconstructed.

As the delta was built out across northern England and the Midlands, it brought brackish water or fresh-water conditions to the area, huge stretches of mudflats and sandbars, perhaps resembling those of the mouth of the present-day Mississippi. These delta deposits are called the Millstone Grit. Periodically the Millstone Grit delta was flooded by the sea, but bands of marine rock become rarer towards the top of the series and are rare in the succeeding Coal Measures. By Coal Measures times the delta had thoroughly established itself, and the deposits of this period represent the mudflat sediments (now shales), and sandbanks (sandstones) of the delta flood-plain, which was traversed by sluggish distributaries, and periodically colonised by a lush swamp vegetation whose highly compressed remains now form seams of coal.



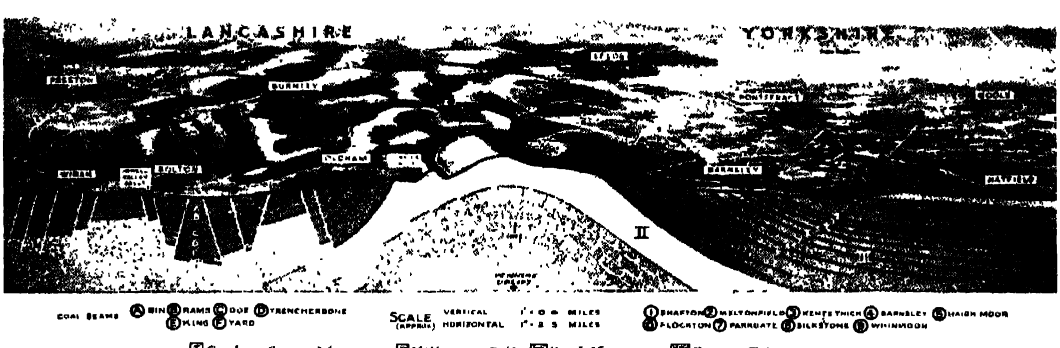
MILLSTONE GRIT PERIOD. This map shows the probable distribution of land and water at the time. A, river bringing schist from the Blair Atholl region; B, bringing porphyry from the Oslo region; C and D, bringing sand, granite, etc.; E, bringing granite, etc.; S, line of section.
From "An Introduction to Stratigraphy," by L. D. Stamp (Allen and Unwin)

The Millstone Grit beds are hard, compact, siliceous strata, flags, and sandstones, together with beds of conglomerate pebbles. The top bed is locally known, in south Wales and elsewhere, as "farewell rock," because it forms the base of the Coal Measures, and it is usually farewell to any further seams as soon as it is reached. Millstone Grit forms the high moorland regions of west Yorkshire, well exposed in the crags at Ilkley, at Pateley Bridge, also in the Harrogate and Keighley districts, and over the Glossop area north of the Peak. These rocks also approach the surface between Lancaster and Settle, and protrude through the Coal Measures farther south. They provide paving stones, and silica stone for fire-bricks.

Coal in Britain

The Coal Measures exist in numerous basins throughout Britain and Ireland. The beds consist chiefly of shales, with lesser beds of sandstone alternating with seams of coal, bands of fireclay, and ironstone. The Coal Measures attain their maximum thickness in south Wales, nearly 10,000 feet in some places, and there are about 25 seams. In Lancashire they reach approximately 8,000 feet, and contain some 65 seams.

In north Staffordshire there are about 40 workable seams. In Durham there are 60 seams, in beds 2,000 feet thick. Leicestershire has 10 seams, in beds approximately 1,500 feet thick. In Northumberland, over a wide area, the beds are between 2,000 and 3,000 feet thick and contain



CARBONIFEROUS COALFIELDS. Diagrammatic section through the Carboniferous coalfields of Lancashire and Yorkshire. Regions of Carboniferous limestone, Millstone Grit, Coal Measures, and Permo-trias are indicated.
Geological Survey and Museum

15 workable seams. In Derbyshire they are approximately 2,500 feet thick, in south Yorkshire and Nottingham about the same —all being part of one great coalfield, which once linked up with the coalfield of Durham and Northumberland. In the Whitehaven area of Cumberland the beds are 1,500 feet thick. In the Forest of Dean are 15 workable seams in beds about 2,500 feet thick. The Bristol and Somerset coal beds are approximately 6,500 feet.

In Scotland the Lanarkshire Coal Measures are some 4,000 feet thick, with 15 workable seams. Others are in Ayrshire, near Edinburgh, in Haddington, Clackmannan, and Fife, where they reach a thickness of nearly 1,000 feet. Cannel coal and oil shales are present near Glasgow. In Ireland the coalfields are very poor, though they are present over large areas of Kerry, Clare, Limerick, Leix, and Kilkenny, with smaller areas in the north.

FIRST CREATURES WITH LUNGS. During the Carboniferous period a warm, moist climate prevailed. Fish, forced to evolve by the preceding Devonian drought, developed lungs and limbs, and so became the first amphibians, but were still mostly restricted to water. Some passed on to the land to become reptiles.

Coal Throughout the World

On the continent of Europe the greatest development of the Upper Carboniferous facies is in Westphalia, Germany, where the whole series attains a thickness of about 11,000 feet, the lower 3,000 feet—called the Flotzeere sandstones—taking the place of the Millstone Grit of Britain. The upper 8,000 feet consists of Coal Measures in which as many as 90 seams of coal are present. This series reappears in the Mons and Douai areas, thinning out through the Boulonnais region of northern France and extending to Kent, where at a depth of over 1,000 feet not very productive seams are worked.

The great development of the Westphalian area has resulted in the adoption of the name Westphalian on the Continent for the strata represented by the Upper Carboniferous in Britain. There are, in addition, certain uppermost Carboniferous beds which do not occur in Britain (except perhaps in south Wales), but are well developed in northern France, where they are known as the Stephanian; in eastern Russia they are called the Uralian.

The Coal Measures in the U.S.A. are the most productive and easily worked in the world, mostly owing to the great thickness of the seams. They are of considerable extent in Pennsylvania, Ohio, and Illinois. Canada has its coalfields, in Nova Scotia.

In Australia the Coal Measures are highly productive. In the New South Wales area, where the Upper Carboniferous merges into the Permian, the strata, intercalated with good coal seams, attain a total thickness of from 11,000 to 13,000 feet, extending over a known area of 25,000 square miles.

China has coalfields rivalling those of the U.S.A., although production there is delayed owing to lack of up-to-date machinery. Elsewhere, Japan, the Donetz district of the U.S.S.R., the coalfields of Poland and of Czecho-Slovakia, and the undeveloped coalfields in the Arctic regions, offer the most promise. Italy and Spain are poorly provided for in this respect.

Flora and Fauna

The Coal Measures are rich in fossils of terrestrial flora, and even fauna, for the forests provided the food and shelter for numerous land creatures, while the mud of the marshy lagoons and deltas preserved their remains. Scorpions such as *Eoscorpius*—a small terrestrial descendant of the big eurypterids of earlier geological periods—were in existence, and insect life attained enormous development; ants, cockroaches, crickets, dragon-flies, may-flies, locusts, beetles, and millipedes have been collected in one locality where conditions were favourable for the preservation of their fossils. Wings of insects reaching to seven inches in length have been found; and there is evidence of creatures with a wing-span of over a foot.

The amphibians belonged to a long extinct type, the labyrinthodonts (named from the labyrinthine folds in their teeth). Several genera of these amphibians have been discovered in Carboniferous rocks in Britian. The flora was abundant and diverse. Lycopods and lepidodendrons were much in evidence. The horsetails (*Equiseta*) are represented. Numerous ferns, many of tree form, flourished. Conifers and araucarias grew in dense abundance.

LESSON 12

Chief Features of the Permian Period

THE Permian is the last of the Palaeozoic periods; its strata follow the Carboniferous, and were originally known as the New Red Sandstone, in contradistinction to the Old Red Sandstone of the Devonian period, which immediately underlies the Carboniferous. Because several other formations, such as marls, breccias, limestones, dolomites, and conglomerates, also enter into the composition of this geological system, the name Permian was proposed by Sir Roderick Murchison, in 1841. It is derived from Perm, an old province of east Russia where these deposits are found extensively developed.

In Britain there exists a distinct break in deposition between the Upper Carboniferous and the Permian series. The highest of the Carboniferous, that is, the Stephanian, facies is not present in Britain, but where strata corresponding to the Stephanian exist, as in northern France, the Carboniferous passes conformably upwards into the Permian. These transition deposits are therefore known generally as Permo-Carboniferous. They are present, together with the Permian, in southern Europe, eastern Russia, central Asia, India, Australia, South Africa, and South America. In these areas they attain a great extent and thickness.

Armorican Orogeny

In Britain the break in deposition between the Upper Carboniferous and Permian rocks was due to an episode of earth movements called the Armorican orogeny (after the old name for Brittany Armorica—where the effects of these earth movements are well displayed). The most severe effects of these earth movements in Britain are seen in Cornwall and south Devon, where the Palaeozoic rocks have been much buckled and fractured. In South Wales, west Somerset, and the Mendip Hills, folding of the Palaeozoic rocks also occurred, and the rucked-up folds tend to an east-west alignment.

The effects of these earth movements make difficulties for miners hewing coal from seams in the South Wales and Bristol coalfields, for these seams are often displaced by faults, and are therefore difficult to follow over any distance. But these earth movements also produced the synclinal basins which preserved some of the British coal formations (as described in the preceding Lesson), for example, in the Midlands, and in Lancashire and Yorkshire.

After the Armorican orogeny, Britain became part of a continent which extended southwards as far as the northern edge of the present-day Alps. The site of the Alps and Mediterranean was covered by a sea known to geologists as Tethys. Britain remained a continental area throughout Permian and Triassic times, except for a short marine invasion of northern England restricted to Upper Permian times. The continental deposits of Permo-Triassic age in Britain contain very few fossils, so that it is difficult to distinguish Permian from Triassic; and most of these deposits are bright red in colour, due to the presence of a fine dust of iron oxide through the rock. So these red rocks are called the New Red Sandstone, the word New distinguishing them from the Old Red Sandstone of Devonian age which lies below the Carboniferous strata.

When the Sea Dried Up

By Upper Permian times the broad and gentle upfolds created in the Palaeozoic rocks by the Armorican orogeny in the Pennine region had already been worn down. Across the bevelled edges of these folds crept a narrow sea, whose deposits can be traced from North Shields to Nottingham, with small patches in the Vale of Eden and near Manchester. The nature of the deposits suggests a very warm shallow sea with a high rate of evaporation of its waters; for the deposits are mainly magnesia-rich limestones, followed by precipitates of gypsum and rock salt, and sealed off above by red clays.

Few fossils occur in these rocks, except in a series of reefs; the waters of this sea may have been too salty for all but a few specially adapted animals. The Upper Permian salt deposits are a great natural asset to Britain; they are worked in Durham. At the end of Permian times the sea dried up, and all of Britain enjoyed continental conditions in Triassic times.

New Red Sandstones

The New Red Sandstones are much in evidence, intercalated with marls and breccias, in the Coventry and Kenilworth areas of Warwickshire, to the west of Birmingham, in the West Bromwich district, and in the northern part of Worcestershire. There are several outcrops in Staffordshire, notably the Clent hills, and in Shropshire where, in the Enville area, the marls, breccias, and conglomerates reach a thickness of 800 feet. These deposits in the Midlands are sands, silts, and pebbles brought down by torrents from highlands which existed in the Worcester and Leicester areas, and in Wales. The torrents were due to infrequent but violent rainstorms, such as characterise the hilly regions of semi-arid countries of the present time.

In Lancashire, on the Pennine slopes to the east of Manchester and Stockport, the New Red Sandstone attains a thickness of 1,000 feet, while the marls and limestones reach to another 230 feet. Farther north, and still to the west of the Pennine ridge, the Permian rocks are found in great thickness throughout the Vale of Eden, reaching almost to Carlisle from Kirkby Stephen in Westmorland. There the New Red Sandstone reaches 1,500 feet in thickness, while above this are thin beds of marine limestone and red shale.

At St. Bee's Head, at Egremont, and farther south in the Clitheroe area, and east of Preston, are more small outcrops of these strata. They appear in the Isle of Man and, still farther west, in Ireland, at Cultra, near Belfast, and at Armagh and in eastern Tyrone.

Rich Red Earth of Devon

In eastern Devon, the well-known red earth is produced by the red marls, soft red sandstones, red conglomerates, and breccia—intensified in the districts north of Torquay by the dark red Watcombe clays, which are used for pottery. Altogether these various strata attain a thickness of about 2,000 feet, covering a large area from Paignton northwards through Torquay, Teignmouth, Dawlish, and Exmouth, to Exeter and thence to Tiverton; a narrow belt extends into Somerset to the Wiveliscombe area. From near Budleigh Salterton, in the east, to Crediton and Hatherleigh, in the west, the country displays the rich red fields, lanes, and combes peculiar to these soft New Red Sandstone strata.

FIRST AGE OF REPTILES. In the Permian period arid conditions arose, backboned animals took to life on dry land, and reptilian forms became established and increased. In this reconstruction the creature with the spiny frill is a herbivorous reptile (Edaphosaurus), 6 ft. long. Beneath it are examples of Cacops, and Eryops. The reptile on the left is a Proterosaurus.

In Scotland there is a small extension of the Cumbrian facies into Annandale, to Dumfries, and to the Thornhill area of Nithsdale, where various beds of sandstones, breccias, and conglomerates attain a thickness of over 1,000 feet; elsewhere these rocks are not much in evidence, a small tract being near Mauchline in Ayrshire, and others in the north, to the east of Elgin, and near Cummingstone.

Great Beds of Rock Salt

The Upper Permian reveals a submergence of part of Europe, particularly Germany, when great beds of limestone were deposited in a sea which ultimately became land-locked, like the present-day Caspian. Desert conditions began to prevail around this shrinking sea. The thick bed of limestone has since become converted into dolomite or magnesian limestone by the magnesium salts dissolved in the saturated waters, which gradually evaporated into salt lakes. Fossils were therefore not plentiful, as these evaporating lakes came to resemble the Dead Sea. Eventually the great beds of rock salt, which are found among the red marls and constitute such a valuable economic deposit in Germany, were formed, together with the extensive beds of anhydrite and gypsum.

Vegetation and Animals

The life of the Permian period indicates a great decline in old forms, which for hundreds of millions of years had flourished, and points to the dawn of a new age, the Mesozoic or Middle Life era. For instance, the last of the trilobites occur in the Permian of North America; the last of the *Orthoceratidae* also, and the *Goniatitidae* of the Upper Carboniferous. The flora of this latter period also came to an end in the Permian.

Certain types of fish also died out, such as the acanthodians; and there occurred throughout the world in Permian times a decided transition to new types of animal and plant. The ammonites took the place of the goniatites; great tree-ferns developed; conifers became numerous, the yew-like *Walchia* flourishing in the drier conditions, together with *Ullmannia*. The earliest types of cycad made their appearance. The araucarias were in evidence, together with the remarkable ginkgo (maidenhair tree), which still survives. Thus we find vegetation beginning to approach modern types.

On land, a new group of backboned animals make their appearance—the reptiles. Reptiles were the first group of four-legged animals to colonise the drier regions of the lands. Most

amphibia must return to water to breed, and the adults live in moist situations or in water. Reptiles lay an egg not dissimilar to that of a chicken, with a tough shell to prevent the egg's contents from drying up, and from which hatches a young animal which is a miniature of the adult and can look after itself. Adult reptiles have a horny, scaly skin which prevents evaporation of body moisture. From the diversity of reptiles present even in early Permian deposits, one can infer that the earliest forms appeared in Carboniferous times ; but it is not until drier conditions become widespread in early Permian times that their remains become common in the rocks.

The Permian reptiles are primitive types, and vary in size from that of a small lizard, such as proterosaurians, to creatures about eight feet long. Some (the small ones) fed on insects ; others were herbivores, such as *Edaphosaurus*, and there were large carnivores such as *Dimetrodon* (not unlike *Edaphosaurus* in appearance). Although these reptiles are often clumsy and primitive in build, already they can be divided into two distinct groups. There are those which, after a series of evolutionary changes during Permian and Triassic times, eventually gave rise to the mammals—the mammal-like reptiles ; and a second stock which gave rise to the diverse groups of the true reptiles and to the birds. But in Early Permian times these two stocks had only just diverged, and the more familiar types of reptile did not appear until Triassic times, and birds not until the Jurassic. Primitive types of the class Amphibia, the labyrinthodonts, still flourished in the Permian as they had in the Carboniferous.

LESSON 13

Deserts and Lakes of Triassic Britain

THE Triassic period is the first of the three divisions into which the long Mesozoic era, estimated to extend over 135 million years, is divided. The Mesozoic (middle-life) was a time of transition from the Palaeozoic or ancient-life era to the Cainozoic or recent-life era, and comprises three periods, the *Triassic*, *Jurassic*, and *Cretaceous*.

It was essentially the era of reptiles, many species attaining enormous dimensions ; whereas the Cainozoic, which covers the last 10 to 20 million years, is regarded as the era of mammals. The Mesozoic era is frequently referred to as the Secondary, according to a somewhat less satisfactory classification.

It must be remembered that while it is necessary for geological classification to regard these eras and periods as distinct, transition from period to period was gradual and continuous. Each *period* is represented by a *system* of rocks or strata, the system being subdivided into different *series*, each bearing a distinctive name and representing a successive *epoch*.

Bunter and Keuper Series

The Triassic system of rocks in Britain is divided into the Bunter and the Keuper series. The Bunter attains a thickness of about 2,200 ft., and is composed of lower mottled sandstone, chiefly red, followed by pebble beds overlain by the upper mottled sandstone.

Above this series is the more extensive Keuper series, which attains a maximum thickness of about 3,500 feet and is composed of sandstone and breccia at the base, with shales, sandstone red marls, dolomitic limestones, and conglomerate, together with beds of rock salt above

The name " Trias," meaning " triple," was given by Von Alberti in 1834, from a three-fold series observed in Germany ; but one series is missing from Britain. This is the Muschelkalk, a marine deposit between the mainly continental Bunter series and Keuper series. It is composed of massive dolomitic limestone attaining a thickness of about 1,000 feet, containing abundant fossils of crinoids and, in particular, bivalve shells (in German, " muscheln "), from which this particular series gets its name " Muschelkalk."

Over the Keuper is a thin transition bed of Rhaetic shales and limestone, which is also generally regarded as Triassic.

Triassic Beds in Britain

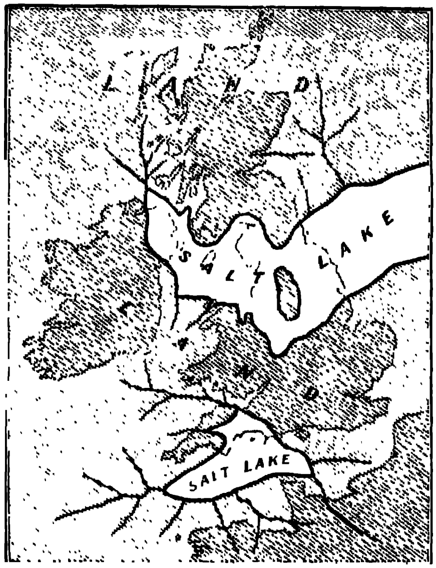
In Britain the Triassic beds approach the surface over the whole of Cheshire, over a large area of south and west Lancashire, nearly the whole of Nottinghamshire, and parts of Durham and Yorkshire, from near Hartlepool and Redcar southward almost to Ripon and York. They continue beneath the recent alluvium of the Ouse and Trent valleys to Nottinghamshire, where, throughout the western half of the county, the Bunter series approaches the surface. Nottingham castle is built on a rock of the Bunter pebble beds.

Over a large area of the midlands from north Staffordshire, Derbyshire, Leicestershire, and Warwickshire, to Worcestershire and Gloucestershire, extend the Keuper beds of the upper Trias ; below these are, over much of the area, the Bunter beds of the lower Trias. These latter approach the surface without the superimposed Keuper in west Cheshire, including Chester, and

most of the Wirral, north Shropshire—where the Bunter pebble beds are chiefly in evidence—and in the Manchester and Liverpool areas of south Lancashire.

Northwards the Bunter facies extend to Furness and the Cumberland coastal area to St. Bees, where they attain a thickness of about 1,000 feet. Borings in the Isle of Man have also revealed their presence.

The Bunter cover a large area of the Vale of Eden, and although the Keuper series covers them in the Carlisle district, they extend into Scotland to the Dumfries district and form some isolated patches in Dumfriesshire and Ayrshire. An area of the Bunter bright red sandstone in the Isle of Arran reaches to about 1,000 feet in thickness; elsewhere it is evident only in Elgin, to the west of Lossiemouth.



TRIASSIC BRITAIN. At the commencement of the Triassic period a large part of Britain was composed of desert. Then the land sank and two great salt lakes came into existence, which in the course of long ages gave place to desert conditions once more.

The Bunter deposits of the Midlands and neighbouring areas represent variable conditions. Many of the pebble beds are torrent deposits, brought down by infrequent rainstorms from the highlands existing over the site of Wales, near Leicester and Worcester. Other deposits are those of temporary shallow lakes and pools. Often, long periods of dry conditions allowed the winds to heap up piles of sand dunes. In Keuper times shallow saline lakes became established, each with limited access to the sea, from which its salty waters could be renewed.

In the hot dry climate the lake waters were steadily evaporated, and layers of salt precipitated on the lake floor. In Cheshire these built up to a thickness of over 800 feet, and they form the basis of an important industry. Elsewhere they are thinner. Smaller shallow saline lakes existed in south Gloucestershire, and south of the Mendip hills, where thin salt deposits of Keuper age also exist. The Gloucestershire deposits include salts of strontium

Throughout a large area of south-east England the Trias formations are known to extend below the superimposed strata of later deposits, borings having revealed the Keuper beds in Northamptonshire and Kent. In Oxfordshire the Keuper series was found about 600 feet below the surface. Over a large area of Somerset and east Devon the bright red sandstone of the Bunter series can be studied conveniently, particularly along the cliff face between Sidmouth and Budleigh Salterton, where it has a thickness of nearly 400 feet, resting upon about 80 feet of the Bunter pebble beds.

Red Breccias

The red marls and sandstone of the Keuper can be well observed on the cliff face between Axmouth, Seaton, and Sidmouth, where they reach a thickness of nearly 1,400 feet. They are also present as red breccias and sandstones round the Quantock and Malvern hills, along the edge of Bridgwater Bay, east of Minehead, in the Bristol area, and in isolated patches across the Channel between Cardiff and Porthcawl. In Ireland the Keuper is chiefly in the Belfast area, along the shores of the lough, and in the valley of the Lagan, where Bunter is also observed. The two are well presented in the Red Bay area of Cushendall and on the east side of Lough Foyle, and small patches occur here and there in Tyrone and Londonderry.

Triassic Flora and Fauna

British Triassic rocks are very unfossiliferous. The only animal which is at all common is a tiny crustacean which houses its body in a bivalved shell. This small crustacean, *Estheria*, still lives to-day and is a common inhabitant of temporary pools of fresh or brackish water in arid or semi-arid countries. It produces eggs which are highly resistant to drought, so that as the pools dry, the eggs remain dormant in the dry mud, to hatch at the next rains.

Other British fossils are few. They have been found at a few scattered localities, as at Elgin in Scotland, where about a dozen different kinds of reptile were discovered; at Bromsgrove in the Midlands, where a small flora of plants and some scorpions were found; and at Durdham Down in Bristol, where the remains of an early type of dinosaur were brought to light.

Fortunately, other parts of the world have yielded a good flora and fauna. These show that conifers and cycads were abundant, as were the horsetails, and some types of fern. The earliest known moss has been found in British Triassic rocks though some very

TRIASSIC PERIOD. Regions where rocks of this period come to the surface in Britain.

fragmentary late Carboniferous remains may possibly be mosses. A petrified forest of conifers has been discovered in Arizona, the tree trunks perfectly preserved, with their bark attached.

First Mammal Appears

The Triassic was an important period in reptile history, for at this time appeared the first members of groups which survive to the present day—lizards, turtles, and crocodiles. The earliest crocodiles looked very unlike their modern descendants; they were quite long-legged agile terrestrial animals. Another group of Triassic reptiles almost perfectly mimicked the form and presumably the habits which are seen in the modern semi-aquatic crocodiles. These were the phytosaurs; but they died out at the end of Triassic times, and the crocodiles then took over their role in the streams and lakes. Various extinct groups of reptiles appear for the first time in Triassic rocks. The ichthyosaurs, wholly aquatic reptiles which resembled the modern mammalian dolphins, but had an upright tail-fin, make their first appearance, though they are commoner in Jurassic and Cretaceous rocks. The first dinosaurs appear, both carnivorous and herbivorous types.

FAUNA OF THE TRIASSIC. **Evolution now took place towards mammalian forms, which made their appearance towards the end of the period. The large creatures seen here are Cynognathus (top) and Kannemeyeria (lower). Both are representatives of the Theriodontia or mammal-like reptiles from which mammals have descended.**

Most important of all animal development was the appearance of the first mammal. This was a small creature, *Microlestes*, which is believed to have resembled the monotremes—a group of primitive mammals of which one of the last two surviving representatives is *Ornithorhynchus paradoxus*, the duck-billed platypus of Australia. The age of great dinosaurs was at hand, but a hundred million years were to pass before mammals were to dominate the world.

LESSON 14

The Strata and Fauna of the Lias

The Jurassic period is named after the Jura mountains between France and Switzerland, where its typical rocks are exceptionally developed. The entire period is well represented in Britain, where it is divided into the Lower Jurassic or Lias, Middle Jurassic or Dogger, and Upper Jurassic or Malm. Further sub-divisions are of two kinds. The first, based upon fauna, is into a number of stages which, in theory, can be recognized all over the world. The second is based on the different rock-types that occur, such as "Forest Marble," "Oxford Clay," and "Cornbrash," which can be applied only locally.

The Jurassic Sea

Throughout the Mesozoic era the broad structural pattern of Europe changed very little. To the south, the geosynclinal trough of Tethys continued its steady progress, while, as in the Trias, Europe north of the northern edge of the Alps fell within the epicontinental area. In Britain the change from Triassic to Jurassic times was the occasion for a widespread submergence under shallow "shelf-seas." The depressions in the arid Triassic landscape were flooded in Rhaetic times, and these lagoons were able to support a poor fauna. With increasing depth of the sea, a more truly marine fauna could immigrate and survive.

The Jurassic sea, though widespread, did not cover the entire country. Cornwall and most of Wales remained as dry land, as did the Pennines, whose relief had been renewed by uplift. The major part of Scotland was never submerged, but scattered deposits show that an arm of the sea covered the Hebrides and part of Northern Ireland, and a similar arm, probably linking up with the Boreal Ocean, ran up the east coast. In south-east England the London–Ardennes land-mass remained above water, but successive periods saw the gradual encroachment of the sea, until in Cretaceous times this land-mass was finally submerged.

Within the area covered by sea, subsidence did not proceed everywhere at the same rate. Along certain lines, such as the E.–W. line of the Mendip hills, subsidences were so slow, by comparison with the adjacent areas, that they are called "axes of upift," or, more simply, "axes." Over the Mendip axis the Jurassic rocks are either thin or absent, but to the

beneath east Leicestershire they attain a thickness of 700 feet in Lincolnshire, and through central Yorkshire to the coast between Redcar and Whitby, where they are over 700 feet. Lower Lias deposits are present to the west of Carlisle and over a few isolated patches along the coast of Antrim. In Scotland they are found in a few areas of Argyll, in Mull, and as far north as Raasay and Broadford in Skye; in Sutherland they occur beneath Dunrobin castle. These are but remnants that have survived denudation, their presence

south, in the Dorset basin, and to the north, in the Cotswold basin, subsidence was relatively rapid and a great thickness of Jurassic rocks was deposited. Two other major axes are known, the first running through Moreton-in-the-Marsh and Oxford, the second in an E.-W. line near the Yorkshire town of Market Weighton.

The history of Jurassic times is an account of the initial flooding of Triassic depressions, their expansion into more or less separate basins of deposition, and finally, towards the close of the period, the retreat of the sea, until in Purbeck times the last remnant of once extensive seas was a small, nearly land-locked lake in south-east England. Such a sequence of events, from terrestrial conditions to marine, then back to terrestrial, is called a "marine cycle."

LIASSIC FORMATIONS IN BRITAIN. **Top left, an isolated block of Middle Lias sandstone on a pillar of shale, on the foreshore at Sheepstone, Yorks. Lower, Upper Lias cliffs at Saltwick bay, Yorks.**
Courtesy of the Geological Survey and Museum

indicating roughly the extent of this northern inlet of the Liassic Sea.

The Middle Lias beds consist chiefly of blue micaceous clays resting upon sandy clays and overlain by yellow sands, clays, and a bed of ferruginous limestone which varies in thickness from about a foot in southern England to 150 feet in the Cleveland district of Yorkshire (where it is of great economic value), and also in the Midlands. The beds of the Middle Lias attain a thickness of about 350 feet in Dorset, and can be seen to advantage in the cliffs between Charmouth and Bridport.

Like the Lower Lias, these beds extend beneath Somerset, Gloucestershire, and other areas, appearing more particularly at Glastonbury, Yeovil, Banbury, and the famous escarpment of Edge Hill. In these areas the valuable ferruginous limestone reaches about 25 feet in thickness. In south Lincolnshire, in the Grantham area, the Middle Lias attains considerable thickness; then, after thinning out beneath the Humber and Derwent area, it thickens into the valuable outcrop of north Yorkshire.

There the ferruginous deposit of "marlstone" or ironstone reaches a thickness of 150 feet, and its proximity to the thick seams of coal

Lias Rocks

The rocks deposited in the early part of this marine cycle are called the Lias, a name originally given by quarrymen to the hard limestones which were at the base of this series; subsequently it became applied to the whole facies. These consist of the following beds: *Lower Lias*, white and blue limestones alternating with shales and clays; *Middle Lias*, beds of sandy clays, shales, and marlstone; and *Upper Lias*, clays intercalated with thin beds of limestone.

The Lower Lias strata rest conformably upon the Rhaetic transition beds overlying the Trias. They are well displayed along the cliffs of the Dorset coast, from Lyme Regis to Bridport, attaining a thickness of about 500 feet. They stretch across the width of England in a belt, as far as the Yorkshire coast; extend beneath Somerset, appearing at Watchet and in quarries near Ilminster; pass round the Mendip hills and across the Bristol Channel, where they are well exposed in the cliffs between Penarth and Dunraven Castle.

The Lower Lias beds have been found by borings in Gloucestershire, Oxfordshire, and Warwickshire to be 450 feet thick; passing

in the adjoining districts has been a great source of wealth to Yorkshire. Only a small residue of the Middle Lias is found farther north—in the Inner Hebrides, at Scarpa, Raasay, and Mull.

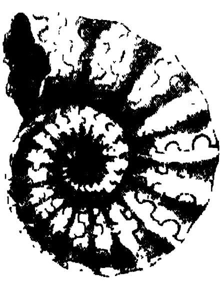
The Upper Lias also extends from Dorset to the Yorkshire coast, where it can be easily studied at Whitby in particular. The beds are best developed in Northamptonshire where, composed mainly of dark clay, they are nearly 160 feet thick, and in Yorkshire where, chiefly composed of blue shales and alum shales with overlying sands, they reach to 330 feet in thickness. They are also present in small areas above the Middle Lias in the Hebrides, attaining a maximum thickness of about 80 feet; and are in evidence more particularly at Northampton, Lincoln, Yeovil, and Ilminster, chiefly in quarries and cuttings, where numerous fossils are present.

DINOSAUR SKELETON, excavated in Alberta, Canada, in 1912. It was complete except for the point of the tail. The bones were little crushed, and underneath the impression of the skin was preserved.

Liassic Flora and Fauna

The life of the Liassic age has been abundantly preserved in fossilised form under very favourable conditions, and is found to be totally different from much that existed at the close of the Palaeozoic era. The flora consisted largely of palm-like cycads, which were so prolific that the period is known botanically as the Age of Cycads. Equisetums (horsetails) were still plentiful, *Equisetum arenaceum* attaining an immense size. The ferns *Sphenopteris*, *Lacopteris*, and many others, flourished from Triassic times, as did the ginkgo or maidenhair tree family. Conifers were abundant.

The fauna of these times was varied, prolific, and very remarkable. The ammonites had developed into a wide variety of free swimming types, one type soon dying out, to be replaced by another. Thus, in the rocks, a certain type is found over a wide area, but is restricted to a small part of the vertical succession. A group of rocks characterised by a certain fossil, or a number of fossils, is called a "zone." The rocks in which, say, *Coroniceras bucklandi* occurs are said to fall within the *bucklandi* zone. A sequence of these zones has been built, by means of which the *relative* geological age of a deposit can be measured.



AMMONITE of the Triassic period.

Palaeozoic fishes had almost died out, their place being taken by numerous species of which *Dapedius*, *Acrodus*, and *Hybodus* are in the Lower Lias; *Lepidotus* and *Leptolepis* in the Upper. The belemnites had become remarkably abundant, and also the lamellibranchs and gastropods. The brachiopods consist of species of *Rhynchonella* and *Terebratula*.

AGE OF GIANT REPTILES. In the Jurassic period reptiles became masters of every element. In the reconstruction above, the fish-like reptile on the right is an ichthyosaur. The reptile with a long swan-like neck is a plesiosaurus (see fossil, page 1851). Crawling on to the bank is an early type of crocodile, Steneosaurus.

Insect life was abundant, and there appeared the earliest flies, together with the earliest known ants. Reptilia made the greatest advance, for while the labyrinthodonts and anomodonts of earlier ages had disappeared, dinosaurs flourished, and steneosaurs (carnivorous crocodiles 18 feet long) had evolved. Most remarkable were the great swimming reptiles, ichthyosaurs and plesiosaurs. The ichthyosaurs existed in great numbers in the shallow Liassic seas and attained a length of as much as 30 feet; their bodies resembled whales except that the tail-fins were upright, like those of fishes. They had acquired the mammalian function of bringing forth their young alive. The plesiosaurs were sea-reptiles, with a long neck and small head with numerous teeth. They attained a length of 14 feet, and had paddles like the ichthyosaurs.

LESSON 15

The Middle and Upper Jurassic

THE Middle and Upper Jurassic are divided into the following stages :

Upper Jurassic	Purbeckian, Portlandian, Kimmeridgian, Oxfordian, Callovian
Middle Jurassic	Bathonian, Bajocian

These series extend as an escarpment north and north-eastwards from Dorset to Yorkshire. Each division has to be considered separately here, because the beds have so much local differentiation, being largely composed of various clays intercalated with beds of limestone, sands, and sandstone.

Bajocian Stage

The Middle Jurassic deposits extend from Dorset and Wiltshire, through Oxfordshire, Northamptonshire, and Lincolnshire, to the north of Yorkshire. In the south-west they consist chiefly of limestones overlying sands, indicating that a shallow sea covered this area, but clays deposited farther north bespeak estuarine conditions.

In England the Bajocian stage is represented by the Inferior Oolite, which is well exposed from Bridport to Burton Bradstock, and around the Yeovil, Bath, Sherborne, Dundry, and Cotswold hills areas. Though the limestone beds are thin in the Dorset and Wiltshire areas, being between 10 and 21 feet thick freestones and ragstones, attain a thickness of between 100 and 250 feet in the Bath area and east of the Cotswolds. From the Oxfordshire area to Northamptonshire, the Inferior Oolite is composed chiefly of sands and ironstone, in places 60 feet thick.

In Lincolnshire, the limestones form a cliff escarpment as much as 150 feet thick. It is sandy in places, and extends to the alternating limestone and estuarine sandstones and shales of north Yorkshire, which attain a thickness of about 400 feet and can be seen well exposed in the Robin Hood's Bay district and the Blea Wyke area. Elsewhere, this formation is present only in Skye, Raasay, Eigg, Muck, and a few small patches, including the Great Oolite, on the coast of Sutherland and Elgin. Its thickness reaches 300 feet in the Jura area, and nearly 1,000 feet in Provence.

ARCHAEOPTERYX. Having teeth as well as beak, with fingers as well as feathers on its wings, Archaeopteryx (Gr. ancient wing) was a link between modern birds and primitive reptiles. This fossilised specimen was found in the Kimmeridgian of Germany.

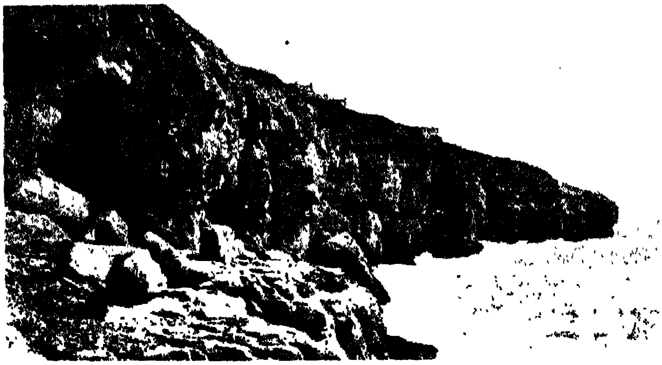
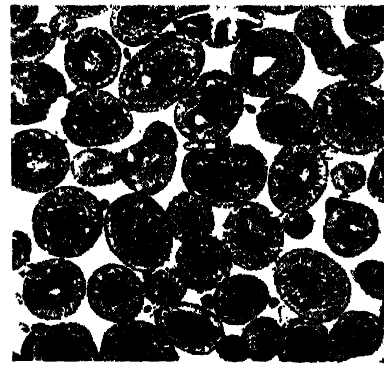
Bathonian Stage

The Bathonian stage extends from Dorset to Yorkshire, adjoining and covering much of the Inferior Oolite. Its various strata attain a thickness of about 250 feet in Dorset and the Bath area, dwindling to 140 feet in Oxfordshire and 100 feet in Lincolnshire. Some parts are very fossiliferous, and can be studied at Bath, Minchinhampton, Stonesfield, Northampton, Bedford, Lincoln, and Gristhorpe Bay on the Yorkshire coast.

The Bathonian rocks show a bewildering variety of rock types, which change with equal rapidity traced horizontally as vertically. Such horizontal, or "facies," changes have already been described from the Bajocian ; here they are even more marked.

The greater part of the Bathonian can be divided into a lower and an upper series, each of which changes its lithology when traced from south to north along the outcrop. In Dorset the lower series is represented entirely by a clay formation, the Fuller's Earth Clay—light grey, marly clays with thin bands of the commercial fuller's earth, which gives the formation its name, and a number of calcareous bands. When traced northwards into the Bath district, white or yellow, highly fossiliferous, oolitic limestones make their appearance above the clays. This is the Great Oolite which, when it is followed into the Cotswolds, is seen to thicken at the expense of the underlying Fuller's Earth, until in Oxfordshire the Fuller's Earth is completely cut out.

Within the Great Oolite, less well marked facies changes occur, so that none of the individual beds can be traced for more than a few miles. One

PORTLAND STONE CLIFFS near Swanage, Dorset. Named after the Isle of Portland, where it is extensively quarried, this stone is used in building. Fossil shells (right) embedded in Portland stone were revealed during quarrying at Easton. The Portlandian formation consists of beds of limestone and calcareous freestone, up to about 300 feet thick. This material was laid down in the course of many thousands of years.
Geological Survey and Museum

of the most interesting of these beds is the Stonesfield Slate, a thin-bedded, fissile limestone, used locally as roofing slate ; it has yielded a large number of fossil mammals. This is one of the earliest mammalian faunas known.

In Buckinghamshire and Northamptonshire the beds which make up the marine Great Oolite pass one by one into beds which were laid down under deltaic conditions. The lowest beds are the first to be affected, and the process is so slow that even in Lincolnshire there is still a thin Great Oolite overlying this Upper " Estuarine " series. In Yorkshire the transition to deltaic conditions is complete, and the whole of the Bathonian is represented by the Upper Estuarine series.

England's Cornbrash

A similar series of changes can be observed when tracing the upper series of the Bathonian across country. In Dorset it is represented by the Forest Marble, a series of platey, but very fossiliferous limestones sandwiched between marls. In Somerset, Wiltshire, and Oxfordshire, the Forest Marble, named after the Forest of Wychwood, is seen to overlie blue clays with a marine fauna, the Bradford Clay. From Buckingham northwards the Forest Marble begins to pass bed by bed into a series of alternating clays and deltaic sands, the Blisworth Clay, which in turn passes into the upper part of the Upper Estuarine series in Yorkshire.

It has already been mentioned that the boundaries of the stages do not always correspond to the junctions between local rock units. In England the Cornbrash, a series of limestones with occasional marls and yielding a good fauna, is a well-defined lithological unit. Comparison with continental faunas has shown that the lower part of the Cornbrash falls within the Bathonian stage, while the upper part should be placed with the succeeding Callovian stage.

Blue and Brown Clays

Above the Cornbrash come the Kellaways Beds, consisting of a blue clay below and sands above, both with a good marine fauna. Overlying the Kellaways Beds are a thick series of highly fossiliferous clays, called the Oxford Clay, much exploited at the present time for making bricks. This formation gives its name to the Oxfordian stage, but two-thirds of the Oxford Clay fall within the Callovian stage, and within the Oxfordian stage are included the highly variable series of limestones, marls, and clays of the Corallian formation.

The Oxford Clay above the Kellaways Beds consists of stiff blue and brown clays with septarian nodules and butuminous shales. They vary in thickness from 170 to 600 feet, extending from Dorset to Scarborough. This formation indicates a muddy deposit, estuarine probably, in which lamellibranchs, ammonites, and belemnites were abundant, judging by their fossil remains. Plesiosaurs, ichthyosaurs, megalosaurs, crustaceans, and insects also flourished.

Coral Limestone

The Corallian indicates the changed conditions of the succeeding age. This formation is so named because of the masses of reef-building coral existing in its shelly limestone beds, which indicate that the water was warm enough for patches or " spreads " of coral reefs to be formed. This is in Dorset, where it reaches a thickness of about 200 feet, extending northwards through Wiltshire and Oxfordshire. There are also valuable beds of ironstone in Wiltshire. In Buckinghamshire, Bedfordshire, Huntingdonshire, and Lincolnshire, the coral limestone is replaced by the Ampthill Clay.

SLUGGISH BRONTOSAURUS. One of the vastest of all quadrupeds, this gigantic reptilian animal was a vegetable feeder. It probably spent most of its time wading in shallow estuaries, but may sometimes have walked on dry land.
Reconstruction by courtesy of the American Museum of Natural History

A prolific fauna flourished. In the limestone, in addition to the coral, there were sea-urchins and ammonites, and the reptiles previously mentioned. The rocks, with the numerous fossils, are well exposed in the cliffs south of Weymouth, at Steeple Ashton, Calne, the Abingdon area, Oxford, Upware in Cambridgeshire, and at Filey, Malton, Scarborough, and the Vale of Pickering, where the beds attain a thickness of 400 feet ; also at Clyne Hill, Sutherland.

The Kimmeridgian

The lowest of the Upper Oolite series is the Kimmeridgian stage, represented in England by the Kimmeridge clay. It consists of dark grey, shaly clays with occasionally septarian nodules and bands of limestone. They attain a thickness of 1,600 feet at Kimmeridge Bay in Dorset, where they are well exposed ; this dwindles to about 300 feet in Wiltshire, and to less than 100 feet in Berkshire, Oxfordshire, and Buckinghamshire. Passing through Cambridgeshire, they thicken in Lincolnshire to 600 feet. In Yorkshire the series is not much exposed, except at Speeton Gap, and the Vale of Pickering.

The strata indicate a muddy and shallow sea or estuary, in which lamellibranchs and cephalopods were numerous, and corals and echinoderms rare. Ichthyosaurs flourished in the sea, together with plesiosaurs and pliosaurs. Pterosaurs or pterodactyls were in the air. Dinosaurs roamed the wide low-lying areas, shallow waters, and marshy stretches which covered so much of south-east England some 50 million years ago.

The Portlandian formation, named after the Isle of Portland, where it is well developed, followed as a consequence of another subsidence of the land. Thick beds of limestone and calcareous freestone were laid down in the course of many thousands of years, until layers approaching 300 feet thick were formed. These are well seen in the cliffs from Durlston Head to St. Aldhelm's Head in Dorset ; other facies appear at Upwey near Weymouth, at Tisbury in the Vale of Wardour, and at Swindon, where the formation has dwindled to about 100 feet thick. It extends to Oxford, Thame, and Aylesbury, but does not appear farther north than Buckinghamshire, though the beds extend a long way south, and reappear in France at Boulogne. The enormous *Titanites giganteus* flourished then, and the coral *Isastraea oblonga*. Portland stone is of considerable commercial value for building.

The Purbeckian formation, named from the Isle of Purbeck, occupies most of this area and is well exposed. It overlies the Portlandian with fresh-water limestones followed by layers of ancient earth—the so-called "dirt-beds"—in which the fossilised stems and roots of Jurassic cycads and conifers have been found. These beds are overlain by a marine deposit in which oyster and other fossil shells figure largely, such as may be seen exposed at Durlston Bay near Swanage, where the strata are 400 feet thick. It diminishes westward to Worbarrow Bay and Lulworth Cove, where it is under 200 feet thick.

The Purbeckian appears also near Swindon, in the Vale of Wardour, and at various localities and cuttings in Oxfordshire and Buckinghamshire, notably at Thame and Aylesbury. The beds come near the surface in parts of Sussex and Kent, and are protruding near Battle.

The fossil fauna of this formation is largely fresh-water and estuarine, in which crocodiles and turtles figure, with numerous fishes and the marsupials *Spalacotherium*, *Plagiaulax*, and *Triconodon*. Insects were prolific.

Gigantic Land Animals

Throughout the Jurassic the dinosaurs were the dominant land animals, and continued so in the Cretaceous. Some dinosaurs attained a large size, such as *Brontosaurus*, 67 feet long and weighing about 30 tons, and the related *Brachiosaurus*, giraffe-necked and about 80 feet long. This group of dinosaurs include the largest animals which have ever walked the lands, yet they were harmless herbivores. They were the prey of the big carnivorous dinosaurs such as *Allosaurus*, 34 feet long.

Purbeck marble, composed mainly of masses of shells of *Paludina*, and found at Swanage, marks the end of the long Jurassic period.

LESSON 16

Survey of the Cretaceous Period

THE Cretaceous is the third and last period of the Mesozoic era; it is named from *creta*, Latin for chalk, the formation which is the most extensive of the Cretaceous series. The lower beds are largely of sand and estuarine origin and therefore of a terrestrial character, composed of clays intercalated with layers of sand, particularly in the series present in western Europe.

The great mass of the Cretaceous rocks are of marine deposition. They are composed chiefly of great beds of soft limestone in the form of chalk, and comprise one of the most extensive and massive of all the sedimentary strata now existing.

World-wide Oceanic Deposit

The Cretaceous facies, as presented in western Europe, extend from Britain (Upper Cretaceous) to northern France, Belgium, north Germany, and the south Baltic area. This area in Cretaceous times constituted a largely land-locked sea, into which were poured the river waters from a vast continent to the north. This Cretaceous sea was separated from a world-wide ocean to the south by an ancient mountainous ridge stretching from what is now Brittany, through the Auvergne and south Germany, to Bohemia. There were then no Pyrenees, Alps, or Apennines, nor any English Downs.

South of this ancient ridge exists the world-wide oceanic deposit, the main Cretaceous beds, extending from Portugal across southern Europe to the Carpathians and south Russia to south-west Asia, including the whole of the Mediterranean area and north Africa, and then extending eastward across Arabia to India, Tibet, south China, and Japan.

All this area was part of the Cretaceous ocean that covered the equatorial regions and divided the large land areas of the northern continent from those of the southern. All except the north-eastern portion of the North American continent was under a vast Cretaceous bed, reaching in the west 13,000 feet in thickness.

The equatorial ocean was the cause of the remarkable diversity which began in Cretaceous times between the fauna and flora of the northern continent and those of the southern. Later on, in the Tertiary era, this became more marked, and it persists to this day in Australia, the last remnant of the southern continent of Cretaceous times. South Africa and South America became united to the northern land-mass in later Tertiary times, but not Australasia, the sole representative of the Gondwana Land of the Mesozoic era.

The Lower Cretaceous series are represented in southern England by the Wealden beds, which consist of Ashdown Sand, the lowest; Wadhurst Clay above; Tunbridge Wells Sand at the top. Above these is the Weald Clay—the whole attaining in south-east England a thickness of nearly 2,000 feet.

The Wealden beds have a total thickness of about 1,000 feet. The Ashdown Sands reach to 400 feet in Ashdown Forest, and compose Crowborough Beacon; they thin out into clay near Hastings. The Wadhurst beds consist of shales and hard clays, and vary between 150 and 160 feet in thickness between Hastings and Wadhurst. They provided much iron ore from medieval times down to the 19th century, when the last iron-furnace was extinguished, at Ashburnham. The Tunbridge Wells Sands consist of calcareous grit, sandstones, shales, clays, and sands, the whole attaining a thickness of nearly 400 feet, but thinning out eastward. All the series just mentioned are well shown in the cliff-face between Hastings and Fairlight.

Weald Clay

The Weald Clay consists of blue and brown clays intercalated with beds of shelly limestone, calcareous sandstone, and sands, the whole reaching to a thickness of about 900 feet. These are well shown along the cliffs of the Isle of Wight, extending along the back of the island from the Atherfield rocks south of Brixton, along Brixton Bay, to Brook. The Weald Clay also extends from Hythe to the Vale of Wardour in the west, but is exposed only in the hollow between the North and South Downs and in some small areas, as in the Isle of Wight.

Farther west the Weald Clay appears in a great mass at Swanage, where its beds reach a total thickness of over 2,000 feet. From there it crosses the Isle of Purbeck to Worbarrow Bay, where the beds are about 1,200 feet thick. The Wealden formation rapidly thins out northward and westward, being little more than 50 feet in the Vale of Wardour, where it is last seen.

Lower Greensand

The deposits of the Wealden series indicate that a great fresh-water basin, known to geologists as the Wealden Lake, covered the southern counties from Dorset to Kent, and also the Channel area to Dieppe and south-eastward to Paris.

The Lower Greensand formation is the first deposit of the transgressive Cretaceous Sea in south-east England—the sands and thin layers of limestone following the muddy deltaic and

freshwater deposits of the Wealden series. The Lower Greensand, or Aptian, is represented, in succession upwards, by the Atherfield, Hythe, Sandgate, and Folkestone beds. They consist of green, yellow, and grey sands, together with layers of clay, limestone, and ironstone—the whole attaining a thickness of about 500 feet in Surrey, 250 feet near Sandgate, and thinning out in other directions. The Hythe beds contain layers of hard limestone, called "ragstone," which is valuable for building purposes. These deposits were laid down during the gradual submergence of the land which began late in Lower Cretaceous times; and beds of alternating sands, clays, and limestones mark a succession of vacillations before the transgression of the sea gave the area an oceanic character.

Northern Marine Beds

In north-east England marine conditions prevailed during Lower Cretaceous times; hence a very different facies is presented in the contemporaneous beds revealed in Norfolk, Lincolnshire, and the East Riding of Yorkshire. These are evidence of the existence of a narrow arm of the sea extending over the greater part of the present North Sea and linked up with the sea which then covered north and east Russia by way of Spitsbergen—in those days more tropical than arctic.

Fossils, particularly ammonites, found in this district of England are singularly like those found in the Russian area, whereas they are totally dissimilar from those ammonites and molluscs found in the contemporaneous beds of southern England. An elevated ridge which appears to have extended from the Charnwood Forest area of Leicestershire to the Ardennes, and part of which is now far beneath London, is believed to have separated these two areas.

The deposits of this northern marine series of beds consist of dark clays and shales, the chief of which is the Speeton Clay, well exposed at Speeton Gap, south of Filey, in Yorkshire. These beds are exposed from Caistor to Tealby, to Spilsby, Candlesby, and Willoughby at the south of the Lincoln Wolds, with a thickness of nearly 100 feet. Thence they extend south to the Hunstanton and Downham Market area of Norfolk, and reappear in a few isolated areas farther south, e.g. at Biggleswade.

Fossils of the Period

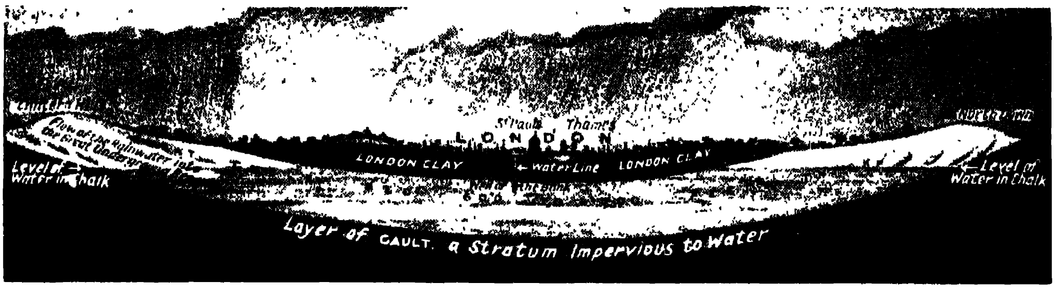
Fossils of both flora and fauna are numerous in favoured situations, the flora in Lower Cretaceous times being very similar to the Jurassic forms. They were of a type that denoted a warm climate even in Greenland and Spitsbergen. Conifers and cycads, together with the ferns *Alethopteris* and *Sphenopteris*, predominated, and plants which were the ancestors of present day flowering trees and shrubs had appeared.

While the reptilian ichthyosaurs and plesiosaurs were declining in numbers, the huge dinosaurs increased enormously, in several species—more particularly *Iguanodon Mantelli*, numerous remains of which have been found in the Tilgate beds in Sussex, and complete skeletons in Belgium. Ammonites and cephalopods flourished in the sea, together with fishes—in particular, *Hybodus* and *Lepidotus Fittoni*. *Lepidotus Mantelli* frequented the Wealden Lake. The Isle of Wight Wealden beds yield fossils of most of the foregoing, including bones and footprints of the iguanodon and hypsilophodon. The so-called "lobster bed," with remains of the crustacean *Meyeria magna*, forms part of the Atherfield Clay.

Gault Deposits

The outstanding feature of the Cretaceous period was the wide spread of sea over land, the greatest taking place during the deposition of the various beds of the Upper Cretaceous series. The process occupied millions of years; thus we find a succession of facies of a very different character revealing the conditions of deposition. The lowest, consisting chiefly of dark bluish marine clays, intercalated in places with sands and chert beds, indicate the wearing down of the land and cliff face of those days, and the deposition of the argillaceous sediment along

TRACHODON DINOSAUR. This uncouth animal lived in Cretaceous times. It was herbivorous, and walked on two feet, using the forefeet to support the body when feeding. It was some 34 feet long and is noteworthy for the prolongation of the jaws, as seen in this artist's impression.



LONDON'S CHALKY BASE. Some 250 feet below London's streets, separated from them by layers of clay, grey sand, and shingle, is a bed of chalk, 600 to 700 feet in thickness, which comes to the surface in the Chilterns and North Downs. Below the chalk is a layer of gault, and as this is impervious to water the rain-water is retained in the chalk, which thus constitutes a vast natural reservoir. An inch of rain yields 14½ million gallons over one square mile, and a fifth of London's water supply is obtained by means of artesian wells sunk down to the chalk.

the margin of the encroaching sea-bed. This deposit is called *gault*.

Above, following this, is a sandy deposit of greenish and sometimes yellowish hue produced by the wearing away of hard rocks of a former age and the re-depositing of them along the sinking shore line of Cretaceous times. This is the Upper Greensand, which together with the gault, is palaeontologically known as *Albian*. These are followed by the series of calcareous deposits called collectively Chalk, divided into Lower Chalk or Cenomanian ; Middle Chalk or Turonian ; Upper Chalk or Senonian.

Gault Clays and Marls

Gault is essentially an argillaceous deposit of marine sediments with occasionally sandy marls, overlain with Upper Greensand. The whole is now regarded as one formation, and it attains a thickness of up to about 300 feet, reaching 200 feet at Maidstone, and increasing to the west through Kent and Surrey to Hampshire, where, near Selborne, it is nearly 250 feet thick. It appears in Wiltshire and the Isle of Wight, where along the Undercliff the gault clays, sands, and chert beds are 240 feet thick.

It is also well displayed at Folkestone in the Warren undercliff ; and in Dorset and Devon, in parts of the cliffs between Lyme Regis and Sidmouth, where it attains a thickness of about 150 feet and is prolific in fossils. In various localities between these towns and the Blackdown Hills the gault appears above the Triassic and Liassic formations. In Berkshire and Oxfordshire the gault clays and marls reach 300 feet in thickness. North-eastward this thins out to 150 feet in Cambridgeshire, to 60 feet in the Stoke Ferry area of Norfolk.

Farther north the gault clays change into the thin beds of " red chalk " so strikingly exhibited in the cliff face at Hunstanton ; but here they are only between 3 and 4 feet thick. These beds appear in Lincolnshire, where at Willoughby they total about 12 feet thick ; and reappear in Yorkshire, where at Speeton Gap they attain a thickness of 30 feet, but thinning out westward. Farther north than Bedfordshire the Upper Greensand and distinctive gault deposits are gradually replaced by clays, which finally become the reddish marls called Red Chalk.

Chalk Deposits

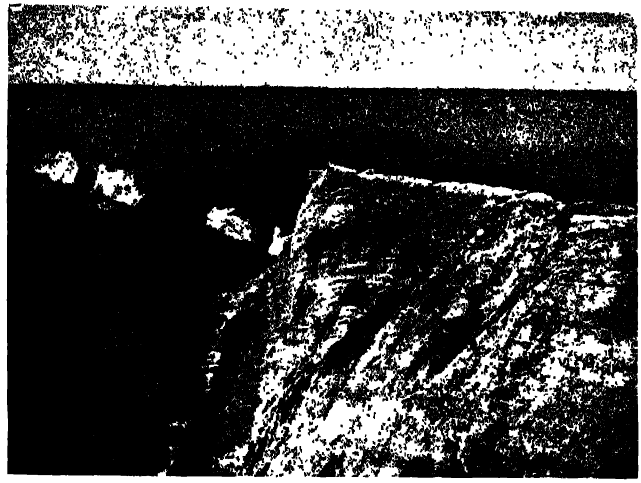
Chalk is probably the most easily recognized of all deposits. It is a very friable limestone, composed chiefly of organic ooze (the organisms are coccoliths). The shells of these tiny organisms, deposited in the course of millions of years on the ocean floor, gradually built up beds over 2,000 feet thick, which are now largely high and dry around the shores of Britain, and from which it was called Albion (Lat. *albus*, white). There are several varieties of chalk, deposited after long intervals of time and under different conditions and after considerable evolution of life forms.

The Lower Chalk has at the base a sandy marl, with glauconite grains giving it a greenish hue similar to the Greensand facies. The Lower Chalk is also known as Grey Chalk, owing to the amount of clayey material in its composition. Numerous fossil sponges, ammonites, etc., occur. Above are deposits of soft grey marl, with belemnites in profusion. This constitutes the Cenomanian stage, the name being given because the beds were first recognized in the Le Mans area of the ancient Cenomanni. The Lower Chalk extends over most of the area of south-east England, beneath the superimposed strata, from Wiltshire and Dorset to Norfolk and Suffolk.

It consists collectively of a bed about 250 feet thick in Wiltshire, decreasing gradually to about 60 feet at Hunstanton, and thinning out further in Lincolnshire and Yorkshire. It is well presented at Folkestone, and also in the Culver Cliffs of the Isle of Wight, where the Lower Chalk attains a thickness of about 200 feet. In Europe it extends eastward into northern France,

Belgium, and Germany ; southwards, it covers most of southern Europe.

The Middle Chalk or Turonian consists of a massive bed of white chalk resting upon a layer of hard nodular chalk, which in turn overlays the soft marl of the Lower Chalk series. The lower portion of this white chalk is without flints, while the upper part is often stratified with flints ; it is well presented in cliff faces on the south and east coasts and attains various thicknesses — 150 feet at Compton Bay, nearly 200 feet in the Culver Cliff of the Isle of Wight, at Ballard Cliff in Dorset about 120 feet ; and, gradually thickening eastward, it reaches nearly 250 feet near Dover. On the east coast the Middle Chalk series are about 100 feet thick in Norfolk and Lincolnshire ; near Speeton in Yorkshire they increase to over 200 feet. Generally they overlie the Lower Chalk series throughout south-east England and elsewhere.



THE NEEDLES. **A colossal bed of chalk lies beneath the surface of a great part of eastern and southern England. It is well exposed along the coasts of Kent and Sussex, and also in the Isle of Wight—which is mostly composed of chalk - where this photograph of the famous Needles was taken. Beyond the outermost of the sharp-pointed pillars of chalk is the Needles lighthouse.**

The Upper Chalk series are remarkable for the layers of black flints with which they are stratified. These flints are siliceous concretions, which often contain fossil shells and fragments as a central nucleus.

The massive white face of the Upper Chalk approaches the surface over an extensive area of England. This colossal bed of chalk is exposed at various places round the English coast, and in many railway cuttings and numerous quarries. At the Needles and cliffs of Afton Down in the Isle of Wight it is well presented, attaining a thickness of over 1,300 feet. Westward in Dorset it averages about 1,000 feet, and it appears throughout the Sussex chalk area, reaching to about 900 feet in thickness. It comprises the cliff face of Thanet and the North and South Forelands, extending from St. Margaret's Bay to near Walmer, the thickness of the bed in these areas being about 500 feet. In Suffolk and Norfolk the Upper Chalk reaches about 1,100 feet ; in Yorkshire, where it is well presented at Flamborough Head, it is over 1,000 feet thick.

Link Between Cretaceous and Eocene

The Upper Cretaceous beds are but little in evidence in Scotland, having been saved from denudation in a few isolated areas by subsequent lava flows in Mull and the adjoining Morven district. The same applies to Ireland, where the Upper Cretaceous beds appear as an encircling fringe of white cliff beneath the black basalt which covers Antrim.

Beds above the Senonian, but not represented in Britain, fall within another stage, the Danian, named from East Denmark, where it is well shown ; it is found also in Sweden and a few patches elsewhere in northern Europe. The Danian represents the only transition beds remaining which connect the Cretaceous with the Eocene, some of the fossil types of the former passing up into the latter ; thus is bridged the break between the last period of the Mesozoic era and the first of the Tertiary.

Cretaceous Flora and Fauna

The flora of the Cretaceous period had already begun to assume the types prevailing to-day, and while ferns such as *Asplenium* and *Gleichenia*, cycads, palms, and various conifers flourished, angiosperms had appeared in profusion. Dicotyledons must have been evolved earlier, for they are found perfected and in abundance at this period—oak, beech, plane, poplar, fig, maple, willow, magnolia, gum tree, cinnamon, buckthorn, ivy, laurel, walnut, alder, cassia, and others, indicative of the long period of time that must have been spanned by the Upper Cretaceous age, probably at least 20 million years.

The fauna of this age exhibited an amazing development, particularly in its reptilian forms. These evolved into giant species and the largest land animals that ever existed, but all save a few diminutive types vanished toward the close of the period. Such were the huge land reptiles, the dinosaurs. The herbivorous *Trachodon*, and a number of diverse related types, flourished. Other herbivores were the horned dinosaurs, resembling rhinoceros, such as *Monoclonius*, 17 feet long. These were preyed upon by

carnivorous dinosaurs, such as *Tyrannosaurus*, 47 feet long and 19 feet high. The sea had its giant reptiles, including *Mosasaurus*, 75 feet in length. The air had its reptiles, the pterodactyls: *Pteranodon* and *Ornithocheirus* are examples.

Toothed birds such as *Hesperornis*, 6 feet in length, *Apatornis* and *Ichthyornis*, resembling the ostrich, but all with reptilian skulls, were plentiful ; only remains of the *Enaliornis* have so far been found in the English Cretaceous beds. Small mammals continued to maintain an existence, but remains of them are very rare, the Upper Cretaceous deposits being largely marine.

The world-wide semi-tropical climate of those times was particularly conducive to flourishing life ; even in north Greenland, tropical ferns, figs, and magnolias flourished. The seas teemed with life all tending to abundance of giant forms. The cephalopods, ammonites, and belemnites were most prolific, and remarkable for size and variety. The lamellibranchs also attained profusion, the bivalve *Hippurites* largely composing the world-wide beds of hippuritic limestone extending over southern Europe, south-west Asia, India, Texas, Mexico, and California. The brachiopods *Terebratula* and *Rhynchonella* were prolific. The sea-bottom was covered with sea-urchins, and there were sponges. Innumerable teeth of various species of shark are found, together with fossil remains of modern fish species such as cod, herring, and salmon.

Apart from its lime products, the Upper Cretaceous system of porous chalk strata is of great economic value as a source of reserve water supply. These porous chalk beds are usually over clay beds which are non-porous, thus creating vast natural reservoirs, which are well adapted for artesian well-sinking where synclines exist, as in the Thames basin and many areas in south-east England.

LESSON 17

First Periods of the Cainozoic Era

At the end of Mesozoic times many groups of animals and plants became extinct and were replaced by more modern types. This pronounced change marks the beginning of the Cainozoic era (Gk. *kainos*, recent, *zoe*, life), some 75 million years ago, in which are included the Tertiary and Quaternary periods. The Tertiary rocks are classified as follows :

(1) Eocene—" Dawn of recent " species
(2) Oligocene—" Few recent " species
(3) Miocene —" Less recent " species
(4) Pliocene—" More recent " species

The first two compose the Palaeogene division, the last two the Neogene division. The Pleistocene—" Most recent " species, and Holocene—" New " species, constitute the Quaternary era, the present Age of Man.

Uplifted Sea Bed

Throughout the Mesozoic era the site of the present day Mediterranean, with some of the surrounding lands, was occupied by a geosynclinal sea, Tethys. In this enormous furrow in the earth's crust were accumulating the sediments which have since been uplifted into the vast mountain chains that run in an east-west direction across southern Europe and Asia. To the north and south of Tethys were shallow shelf seas extending from the ancient mountains of Wales, the west of England and Scotland, which linked up with Scandinavia, to the southern boundary of what is now the Sahara.

A tremendous uplift of the sea bed had set in towards the close of the Mesozoic : the first of the earth movements which, towards the middle of the Tertiary era, were to result in the colossal crustal folds and the formation of the great mountain ranges. But some millions of years intervened before the great calcareous deposits rose above the sea level here and there, thus producing peninsulas and islands, which later formed the numerous countries surrounding the modern Mediterranean littoral.

One such island had risen in a large and partially enclosed sea, which covered south-east England, the north of France from Normandy to the Ardennes, and the Netherlands—the Anglo-Franco-Belgian Basin. The island rose as a great dome, to a height of over 1,000 feet, and extended from Hampshire—along the line of the present North Downs—to Artois, across what is now the Strait of Dover. This Wealden Island, as it is called, formed a partial barrier between the Tertiary rocks laid down in the London Basin and the Hampshire Basin.

Eocene Classification

Meanwhile the material eroded from the landmasses to the north and west was being laid down in the Anglo-Franco-Belgian Basin as the Eocene rocks. Coarse-grained sand is found nearest the margins of the basin, finer grained clays and marls farther out towards the centre. As the sea advanced and withdrew, the boundary between these two facies moved as well, so that in one spot can be seen the near shore sands of one period overlain by the deeper water clays of later times. They are classified as follows.

Thanet Beds. Immediately overlying the Cretaceous are the lowest beds of the series. Pale or greenish sands, with some sandy marl and

THE GIANT'S CAUSEWAY. This promontory of columnar basalt on the north coast of Antrim, Northern Ireland, comprises three causeways—the Little, the Middle or Honeycomb, and the Grand (shown in this photo)—separated from one another by upthrusts of shapeless basalt called whindikes. Some 40,000 polygonal basalt pillars (diameter 15–20 ins.) are closely packed in the Causeway area.

numerous fossils, which are well exposed in the cliffs of Thanet and Pegwell Bay, attain a thickness of 60 feet, thinning to 50 feet in west Kent and vanishing in Surrey.

Woolwich, Reading, and Oldhaven Beds. These consist of sands with grey clays, lagoonal in the west, but marine farther east, attaining a thickness of between 100 and 150 feet between Reading and the Isle of Wight, at Whitecliff Bay.

London Clay. This is a bluish-grey clay changing to a brown tint on atmospheric contact and containing layers of septarian nodules. The clay reaches a thickness of about 500 feet beneath London, but thins out and becomes more sandy towards the west, being only 50 feet thick at Newbury. In the Hampshire area it is always thick, reaching nearly 300 feet at Portsmouth and in the Whitecliff and Alum Bay area of the Isle of Wight. Its abundant fossils are a curious mixture of marine and land types ; these include fishes, molluscs, crustaceans, turtles, crocodiles, sea-snakes, sharks, remains of birds, small plants, palms, modern trees, and many varieties of mammal.

Bagshot Beds. Sands which have been largely eroded, and therefore remain in patches over the London Clay, compose these beds ; they are present over the Bagshot, Aldershot, Farnborough, Wokingham, and Ascot areas, and attain a thickness approaching 150 feet in the Bagshot district. North of the Thames they are much more denuded, occupying small areas at Highgate, Hampstead, and Harrow, on the high ground. In the Hampshire area and that of Alum Bay in the Isle of Wight the light coloured sands are laminated with clays, and attain thicknesses varying between 300 and 600 feet.

Bracklesham and Bournemouth Beds. Composed of laminated clays and sand, these beds are between 200 and 300 feet thick. They can be seen at Bracklesham Bay in Sussex, at Whitecliff Bay in the Isle of Wight, at Bournemouth, and at Hengistbury Head. The sands and clays of this series exceed 500 feet in thickness in this area.

Barton Beds. These consist of clay overlain by sand. They are nearly 200 feet thick at Barton, where they are well shown to the east of Christchurch, and also at Alum Bay and Whitecliff Bay, where they exceed 300 feet.

Above the Eocene series are further thinly bedded deposits of sand, clay, marls, and thin limestone layers in the Isle of Wight and New Forest areas. For a time conditions were similar to those found in the Eocene, but while Oligocene Beds were still being deposited in the south of France the English area was uplifted and deposition ceased. In England the following divisions are recognized.

The Headon Beds. These are composed of clays and sands intercalated with thin beds of limestone, the whole comprising a marine facies and approaching 150 feet in thickness. Well exposed at Headon Hill and Whitecliff Bay ; extending beneath the New Forest, Brockenhurst, and Lyndhurst.

The Osborne Beds. Fresh or brackish water sands and marls.

The Bembridge Beds. Marls very similar to the Osborne Beds, overlain by a limestone full of fresh water gastropods such as *Limnaea* and *Planorbis.*

The Hamstead Beds. Composed of marine deposits of marls and clays with numerous fossils of land plants, indicating that land was not far away ; the beds attain a thickness of about 250 feet.

In addition to the Hamstead Beds, which are the uppermost of the series, there are in the Bovey Tracey area of Devonshire a series of fresh-water sands and clays which, from the fossil plants found embedded, suggest formation in late Oligocene times, though they have been ascribed to the succeeding Miocene period.

Over southern Europe the Eocene deposits were most extensive, and attained a thickness of 3,000 feet in many areas. They consisted largely of nummulitic limestone, so named from the great proportion of the remarkable nummulites, or disk-shaped foraminifera, in its composition. These massive beds extend from the Pyrenees to the Caucasus and Egypt.

In Middle Eocene times, volcanoes began to appear over a wide area from the Western Highlands of Scotland to Iceland. This burst of vulcanicity had almost died out by the end of the Palaeogene, but in Iceland there is activity to the present day. The sites of the actual volcanoes can be recognized by the large bodies of coarse-grained igneous rocks which solidified slowly in the magma chambers; the cones themselves, much softer, have been eroded away.

Basaltic Columns

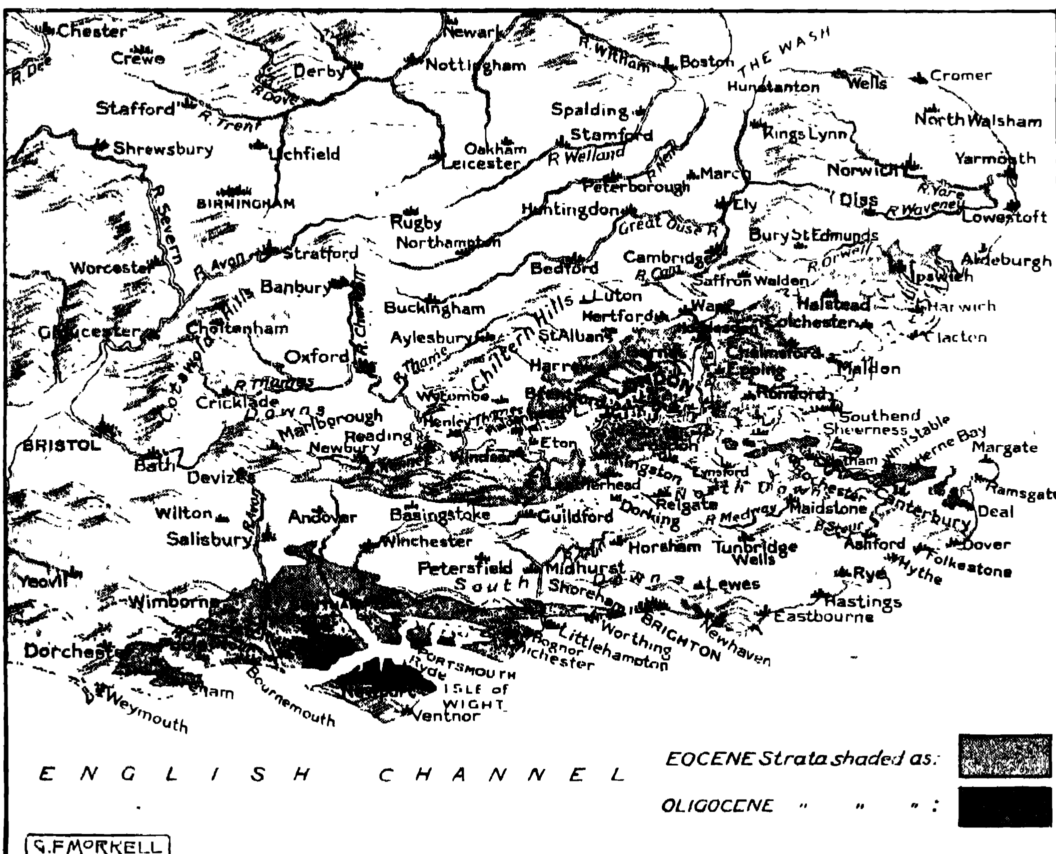
The most famous of these "igneous complexes" can be seen in the Hebrides, on the islands of Skye, Mull, and Arran, and in Antrim at Slieve Gullion. From these scattered centres vast flows of basaltic lava were poured out, which were rapidly cooled on contact with the air and developed a hexagonal joint pattern. Subsequent erosion has eaten into the lava flows along the line of these joints, leaving "columns" of basalt such as can be seen in the Giant's Causeway of Antrim, and Staffa in the Outer Hebrides, famous for Fingal's Cave.

At the end of the Mesozoic, many of the dominant groups of animals died out. The ammonites, so common throughout the Jurassic and Cretaceous, completely disappear and their place is taken by the other two groups of molluscs, the lamellibranchs and the gastropods. Among the vertebrates, reptiles, dominant on land as the dinosaurs, in the seas (ichthyosaurs and plesiosaurs), and in the air (pterodactyls), lose their place to the mammals, which right at the start of Tertiary times are rapidly evolving into the most varied types.

Mountain Building Phase

Since it was in the Alps that the extent of this mountain building phase, or "orogeny," was first elucidated, mountain ranges throughout the world that were folded in Neogene times are said to belong to the Alpine Orogeny.

In North Europe, where the Palaeozoic rocks had been folded and compressed in the earlier Caledonian and Armorican orogenies, the effects of the Alpine earth movements were not nearly as strong. The Mesozoic and Tertiary



EOCENE AND OLIGOCENE PERIODS. **Sites in England of geological beds of the early Tertiary era.**

DINOCERAS: AN EOCENE MONSTER. Most of the small mammals of the early Eocene period progressed in complexity and brain-power till they became the creatures we know to-day, but some advanced in bulk without any increase in size of brain. The Dinoceras ("Terrible Horn") of North America, seen in this reconstruction, were exterminated by their better-equipped rivals.
Reconstruction by C. R. Knight, American Museum of Natural History

were thin, compared with the Tethyan sediments, so that at no great depth there was a resistant "basement" of Palaeozoic rocks which were incapable of folding, and would fracture only with difficulty. As a result, the counterpart of the overfolds of the Swiss region is a series of comparatively minor folds, which in southern England are commonly in the form of "monoclines," but are seldom overturned.

Monoclines

A monocline is a fold in which in any one stratum a vertical limb connects two horizontal masses of the same stratum which are at different heights. One of the most famous of these monoclines forms the Hog's Back, near Guildford, in Surrey; two more form the "spine" of the Isle of Wight. It is in the latter area that one of the phenomena associated with these monoclines is seen. At the western end of the island the Chalk of the Needles and the Tertiaries of Alum Bay are seen in the vertical limb of a monocline that can be traced eastwards to the centre of the island. Here it begins to die out; but as its importance decreases, that of another monocline, a few miles to the north, increases, until in the Eocene of Whitecliff Bay the rocks are again vertical.

This arrangement of monoclines can be traced over much of southern England; but more obvious are the broad, though gentle, anticlines and synclines which also occur. In one such syncline, which carries the chalk of the Chiltern Hills deep below the Thames, to reappear in the North Downs, the Tertiary rocks of the London Basin have been preserved. The crest of the complementary anticline to the south has been removed by erosion, so that the Chalk of either side, forming the North and the South Downs, are now separated by as much as 30 miles, and rocks as old as the Upper Jurassic appear in the core.

The fauna was adapted for a warm climate, the most noteworthy types being various tapir-like animals, the *Palaeotherium, Coryphodon, Lophiodon, Paloplotherium*, and *Pachynolophus* of the rhinoceros type, also the *Hyracotherium*, a cony-like creature, and the carnivorous *Palaeonictis* and *Arctocyon*. The dinosaurs *Arsinoitherium* and *Hyaenodon* supplanted the colossal dinosaurs. A stranger had appeared—the lemuroid *Microchaerus*, the first known primate, and the possible ancestor of man.

LESSON 18

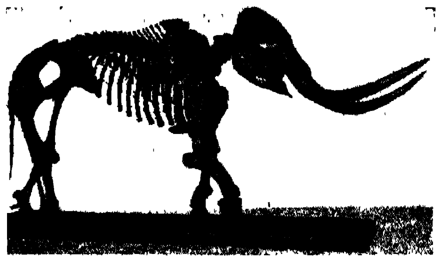
The Folding Miocene and Pliocene World

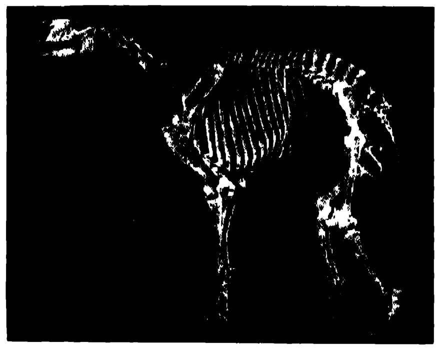
The Miocene and Pliocene periods taken together are now regarded by many authorities as two series of the Neogene system of Tertiary deposits; nevertheless, they were totally dissimilar periods, though the strata and life forms merge, as a rule, without distinctive break.

There are no deposits in Britain of the Miocene period, but they are extensively represented on the continent of Europe, more particularly in the Touraine area of France, in Belgium, over most of Germany, Austria, Switzerland between the Jura and Alps, north-east Spain, Italy, eastern Europe; also in Syria, Egypt, Arabia, Persia, India; in the Atlantic states of North America, and in the Pacific states. Here they are called the Monterey beds, and they attain a thickness of between 6,000 and 7,000 feet. The shales of this series reach to 4,000 feet and are of great value on account of their oil-bearing properties. The Miocene beds are uplifted to high altitudes in the Rocky Mountains, indicative of the chain's comparatively recent raising.

Earth Movements Reach Their Climax

It was during this period that earth movements, whose effect can be seen as far back as the Triassic period, rose to their climax. Along the line of the Tethyan geosyncline, where a great thickness of sediments had recently





FAUNA OF THE MIOCENE. Fossilised skeletons of (above) Hippotherium or Lipparion; top right, Mastodon; lower right, Moropus ("slothfoot").
American Museum of Natural History, New York

been deposited, this folding found its greatest expression. Throughout the Jurassic, Cretaceous, and Tertiary, islands began to appear within the geosyncline, in lines running east and west, which marked the high points of long submarine ridges.

During the Miocene period these ridges were forced upwards, to become enormous overfolds or "nappes," which were piled one upon the other until a heap of folded rocks replaced the one-time geosyncline. Subsequent erosion of these rocks has carved out the separate peaks seen to-day in the Alpine and Himalayan mountain chains.

Continental Masses

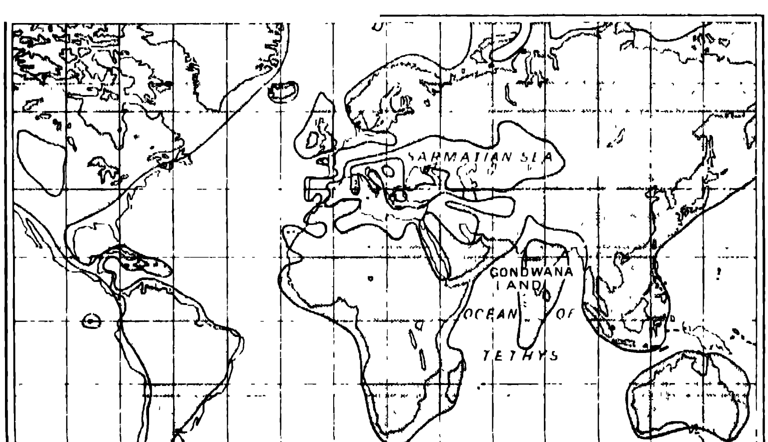
As a result of the widespread upheaval of the Miocene period, Britain became isolated from the warm waters of the Mediterranean; so that when, in the Pliocene period, the sea re-invaded the North Sea Basin, the character of the fauna was quite different from those found in the Eocene and Oligocene.

In the western hemisphere, as in the eastern, continental masses were approaching their modern form. Most of the colossal upraising of the Andes and Rocky Mountains occurred during this Miocene period. Salt lakes formed between the Pacific and the uplifted ranges in the extensive valleys of the synclinal folds. The Great Salt Lake in the state of Utah, U.S.A., is the largest survivor of these basins, but very much diminished. Its area is now some 2,000 square miles.

Africa having become united to Eurasia by the upraising of Arabia and connexions with southern Europe, Australia remained as the only segregated continent surviving from pre-Miocene times, with the result that its fauna and flora were henceforth practically distinct and remain so to modern times. Nevertheless, it shared in the world-wide upraising of the land, as the Miocene deposits of Victoria and Tasmania testify. New Zealand also has large areas of both the North and South Islands covered by Miocene deposits, some of which reach 20,000 ft. in thickness.

England's Pliocene Beds

The Pliocene period is probably not much more than a million years distant, and the faunas differ from those of the Miocene in a number of ways. The most striking changes are a result of the deterioration of the climate from the sub-tropical conditions of Miocene



MIOCENE AGE. Land-masses of this remote period are shown stippled and outlined in black.

times, leading eventually to the glaciations of the Pleistocene ; in addition, many species of Pliocene molluscs have survived to the present day. The deposits occupy a large tract of east Norfolk and Suffolk, with the adjoining north-east corner of Essex. They are present as sand and clay at St. Erth in Cornwall.

Over the continent of Europe the Pliocene deposits attain a thickness of about 1,200 feet in Holland, where they are extensive. They constitute a large proportion of Italy, each side of the Apennines to the sea, and reach a thickness of 2,000 feet in Calabria and Sicily. In Austria, Greece, and around the Mediterranean, they form a fringe of beds of varying thickness.

The Pliocene beds in England are divided into the following series :

Cromer Beds (uppermost) · the "forest bed" of peat and tree-trunks, fresh-water sands and silts. Exposed from Happisburgh to Weybourne.

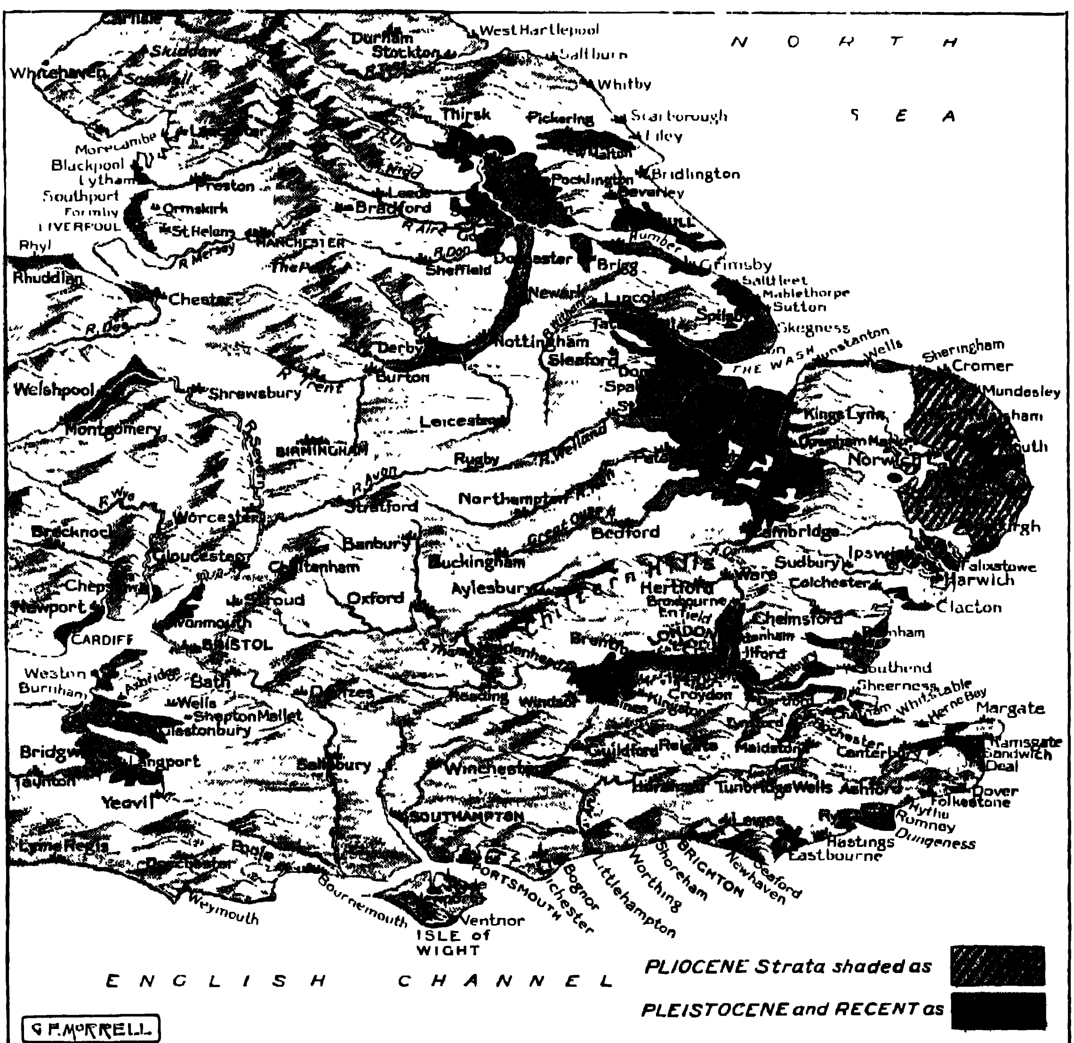
Weybourne Crag : sand, loam, and blue-clay, a marine shelly deposit found at Weybourne

Chillesford Beds : finely laminated clays and sands : traced as a sinuous band from Walton-on-the-Naze to Mundesley over the underlying beds.

Norwich Crag : gravel and shelly sand deposit with laminated clays between 150 and 200 feet thick at Lowestoft and Southwold, where it appears at the base of the cliffs.

Middle

Red Crag · ferruginous shelly sand, the peroxide of iron producing its distinctive colour. Covers an area between Ipswich, Felixstowe, and Walton-on-the-Naze, but only well exposed in valleys and cliffs at Walton, Bawdsey, and Felixstowe.



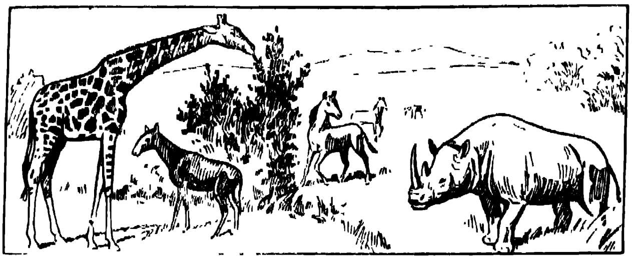
PLIOCENE AND PLEISTOCENE. **Geological remains in Britain before and during the Great Ice Age.**

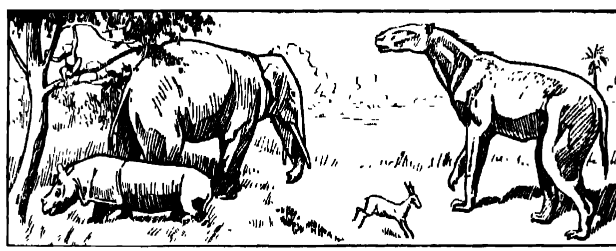
Coralline Crag : fragments of bryozoa, molluscs, crustaceans, with numerous remains of animals, fish, and reptilian vertebrae—all apparently washed out from pre-existing beds. Found between Aldeburgh and Boyton, also in patches elsewhere.

Lenham Beds : lowest and oldest of Pliocene deposits ; brown clay, red and yellow sand, and flint pebbles. Only fragmentary remains exist now on the Downs between Folkestone and Maidstone. Fossil types indicate age.

The life of the series indicates an increasing number of northern forms adapted to colder and colder conditions, while a growing decrease is evident in those suited to a warm climate. The world-wide warmth of the Miocene period throughout Europe enabled a sub-tropical flora to flourish. Even in north Greenland, within 700 miles of the N. Pole, sub-tropical evergreens flourished ; seams of coal 30 feet thick testify to its long duration. In later Miocene times the vegetation became of a more temperate type, and a change is perceptible in the fauna. Beeches, poplars, and evergreens such as laurels took the place of the palms, myrtles, mimosas, fig trees, and magnolias of the earlier time. Monkeys, which had made their appearance, retreated south over a thousand miles.

The fauna of Miocene times is remarkable for the elimination of marsupials from Europe, and the coming of the ape, the sabre-toothed tiger, dinotheria, and mastodons. Bears, hyaenas, rhinoceros, hippopotamus, and tapirs developed, and the anthropoid apes *Dryopithecus* and *Pliopithecus* now made their appearance. In the Pliocene period, wolves and horned deer (*Cervidae*), asses, and antelopes appeared. The dinotheria and some others vanished for good.





FAUNA OF MIOCENE AND PLIOCENE TIMES. Lower : rhinoceros, mastodon, and the extinct Chalicotheres (right), on the grassy plains of Miocene times. Upper : ancestral forms in evidence during the Pliocene period.

LESSON 19

The Ice Ages

The most recent division of geological time is called the Quaternary era. It extends back between 500,000 and 1,000,000 years, and is divided into two geological periods—the earlier being the Pleistocene, or mostly recent, the later, the Holocene, or recent. This brings the palaeontological record down to archaeological and historical times. The Pleistocene deposits indicate a method of deposition largely due to ice and frigid conditions. The Pleistocene is therefore known also as the *Glacial Period* or the Great Ice Age, though the larger temperate and tropical areas remained free from these conditions, and deposits in such areas are normal and generally resemble those of the later Pliocene period.

Evidences of these frigid Arctic conditions are chiefly the extensive masses of detritus peculiar to glaciers, known comprehensively as "drift," since they form the most recent series of deposits, laid down on a topography which was much the same then as it is now. Other evidence is the effect produced by the weight and movement of the enormous glaciers as they pass over the various surfaces of the underlying beds.

Vast Moving Ice Sheets

In Pleistocene times even mountains were buried under vast moving ice sheets compounded of numerous glaciers, which attained a thickness of between 7,000 and 10,000 feet. Their movement was facilitated by the phenomenon called regelation, which consists of constant momentary melting and refreezing of the ice particles, due to changes of pressure. As water freezes, it expands. This simple physical fact has played a large part in the erosion of glaciated areas, because water that has found its way into joints and fissures in the rocks enlarges the joints, and in the end prises away rock fragments, which are then carried along by the

glacier. Rock fragments in a glacier act as if they were the sand grains in sandpaper, so that the glaciers grind the surfaces over which they pass into a smooth or polished condition. Striated and ice-scratched surfaces also result, indicating the line of the glacier's advance.

Thus the rugged mountain masses and volcanic cones of pre-Glacial times became transformed during the Great Ice Age into the rounded masses and gigantic humps which are a familiar feature of the glaciated mountains of Britain and northern Europe, as compared with the angular ruggedness of, say, the Balkans, and the mountains of Greece, of southern Italy, and of Spain, all of which escaped any extensive glaciation.

Moraines

As the glacier progresses, a large quantity of material, chiefly rocks, sand, and clay, is collected on each side as it erodes its way; these are called moraines. The mass of detritus is carried along until it becomes heaped up as a vast and ever-growing deposit of debris at the lower extremity of the glacier, where it is known as the *terminal moraine*. Or it may become spread out fan-wise over a large area by the rushing streams which emerge from glaciers, and will flood the country around.

Thus materials of strata and rocks become transported hundreds or even thousands of miles and, while having totally different character, are deposited as a compound mixture of stones, clay, sand, and pebbles, in which are frequently great boulders, and fragments of fossils, such as bones, tree-trunks, and mammalian teeth and tusks, all of which have been collected on the way.

This deposit, which may attain hundreds of feet in thickness, is called *Boulder Clay*; the harder kinds are called *Till*. Thus is formed the most characteristic deposit of the glaciers of Pleistocene times, proving that northern Europe was covered by a vast ice sheet, which flowed chiefly from Scandinavia and reached, when at its greatest extent, from the Urals to the Atlantic Ocean and as far south as the Harz Mountains.

Four or Two Glacial Periods?

Two great Glacial periods can be traced as emanating from Scandinavia, though evidence is found of four periods in the Alpine area; these are called the *Günz*, *Mindel*, *Riss*, and *Würm* periods. Consequently, certain authorities regard Europe as having been subject to four Glacial periods, but some recognize only two, the others being but minor fluctuations which did not extend to Britain or far beyond the Scandinavia region.

The first period, or Günz, radiating from the mountainous mass of Scandinavia over what is now the Baltic and Finland area, did not approach the British Isles, which then formed an integral part of the European continent.

BRITISH ISLES IN THE ICE AGE. These areas of glaciation were distinct from the still vaster ice-sheets which spread from Norway over what is now the North Sea and as far south as the present Thames valley.

During a temporary recession Iceland became severed in a general sinking of the land, of which there is evidence extending to at least 100 feet around the present Scottish coasts: then came the second (or first great) period of extensive glaciation.

This, known as the Mindel glaciation in the Alps, but recognized in Britain as being the origin of the North Sea Drift of East Anglia, must have been a period of considerable atmospheric moisture, with prolonged low temperatures. This caused vast sheets of unmelted snow to descend as glacial ice from the elevated Scandinavian area over what are now the Baltic and North Sea regions, where the wall of Scandinavian ice met a lesser one descending from the Scottish Highlands, which spread over Ireland. Together, this slowly travelling mass, with a thickness which ultimately reached some 5,000 to 7,000 feet over Britain and 10,000 feet over the Baltic area, spread to the traceable limits called the second glacial period.

The only part of the British Isles region to escape was that to the south of the Thames and the Bristol Channel, where there is evidence that an arm of the warm Western Ocean, now the Atlantic, penetrated from earlier times. Much material of the Norwegian mountains was deposited in the Boulder Clay and as large erratic blocks over England ; as far south as the Thames Valley is conclusive evidence of the extent of the glaciers.

British Glaciers

In Scotland both the Grampian and Gallowegian areas had developed glaciers which, together with those of the lesser areas of Cumberland, the Cheviots, Pennines, and Wales, formed an ice sheet, in places estimated to reach 5,000 feet thick. This ice sheet held back and diverted the course of the Scandinavian ice. The deviation appears to have occurred in the Cleveland district of Yorkshire, which, with central and south Yorkshire, remained singularly free from ice. The ice spread out over the lowlands, while the Welsh glaciers covered Wales to the Bristol Channel.

The Scottish ice poured down over most of Ireland, filling the Irish Sea area with an ice sheet which covered even the 2,034-foot mountain of Snaefell in the Isle of Man. This glacial sheet also spread out westwards over the Hebridean area, completely covering what are now the Hebrides, and extending to the Atlantic, where it presented a wall of ice ; from this, enormous bergs floated away over the Atlantic—as they do now from Greenland. Some big icebergs landed as boulders on the Scilly Islands.

In North America the glaciation was even greater than in Europe. It reached a thickness of from 7,000 to 15,000 feet, the glacial drift being spread out as far south as 37° of north latitude, whereas in Europe it reached only to about 50°. There are also evidences of extensive glaciation in South America, Tasmania, and New Zealand, where the ice attained a thickness of 7,000 feet.

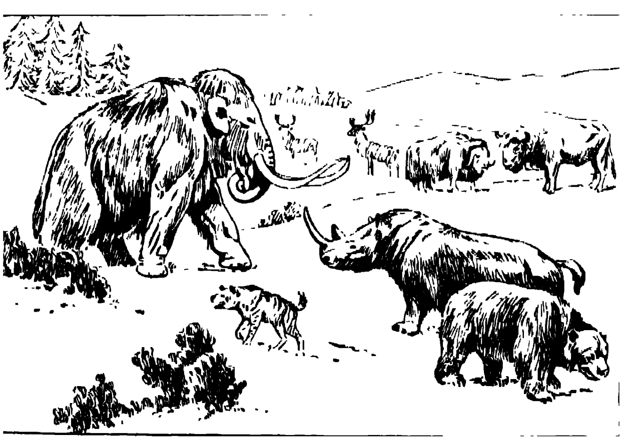
Ultimately the enormous weight of the vast sheet appears to have had some effect upon the earth's crust, for later on the land of north-west Europe appears to have sunk to a much lower level, and eventually much warmer conditions ensued.

Interglacial Period

The Great Interglacial period extended for well over 100,000 years. At first tundra, then steppe conditions prevailed and followed the retreating glaciers, which left behind cold morass and all the moraine detritus which is such conclusive evidence of their one-time presence. This was followed by immense quantities of fine wind-blown dust and sand from more southern regions, which piled up into layers called *loess*.

This loess surface became ideal for the development of a grass steppe area such as exists over much of central Asia at the present time. Elephant, rhinoceros, sabre-toothed tiger, elk, horse, and aurochs, roamed the plains which extended unbroken all the way from the Severn to the Urals.

Forests followed, and spread, with bears and forest life, much of which has continued to the present time. The hippopotamus inhabited the river that flowed through the plain that is now the North Sea and whose tributaries were the Thames, Rhine, and Elbe. Warm winds prevailed, with warm cyclones and currents from the Western Ocean, perhaps originating in the Pacific. Climatic conditions were favourable to the existence of Palaeolithic man He began to develop and flourish, leaving increasing evidence of his presence, chiefly in the form of flint implements, in what is now southern England and central and western Europe.

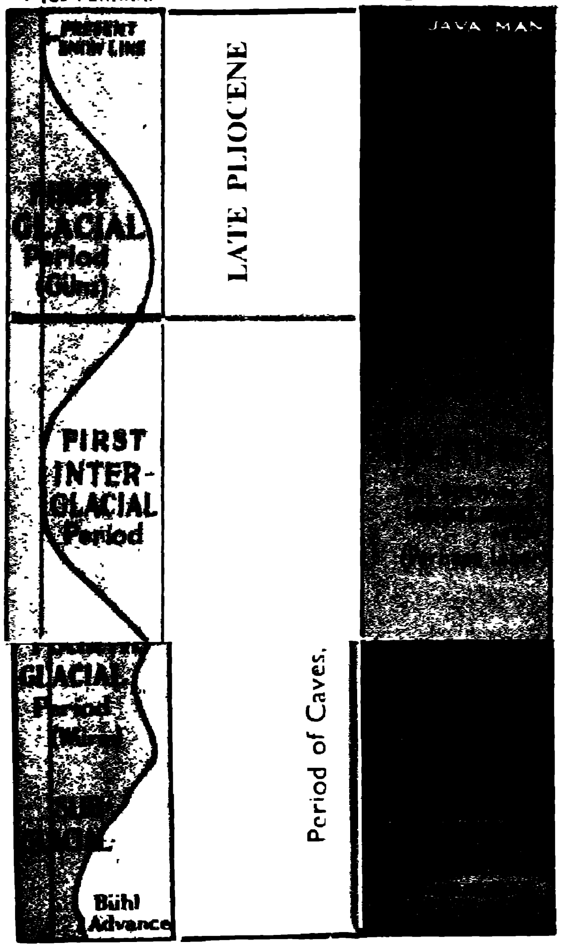


IN GLACIAL TIMES. With the spread of the glaciers over Europe a group of animals adapted to withstand the cold replaced the warmth-loving fauna ; such were mammoth, woolly rhinoceros, cave-bear, bison, and others. Primitive man, hunters of the Mousterian culture, also appeared in later Glacial times.

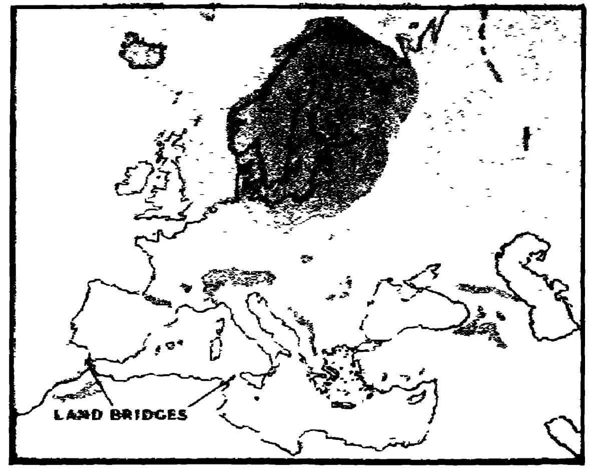
Then something geographical or meteorological happened, most probably one in consequence of the other; and the Highlands of Scotland, together with those of Scandinavia in a much greater degree, became covered with repeated snowfalls beyond the capacity of the summer sun to melt fast enough ; and another vast ice sheet formed, increased, and spread. This, the Riss glaciation of the Alps and the Great Eastern of East Anglia, was not so

RELATIVE LENGTHS OF ICE PERIODS

HUMAN TYPES & CULTURE



HOW THE ICE SHEETS ADVANCED AND RECEDED DURING THE FOUR GLACIAL PERIODS



FIRST GLACIAL PERIOD. This, known as the Gunz glaciation, was, as one might expect, the mildest of the four glacial periods. It did not involve the British Isles, but a study of Alpine and of Scandinavian sites has established its identity. Note the differences from the modern coastline

FOURTH GLACIAL PERIOD. The land bridges across the Mediterranean that characterised the glacial periods played an especially important part in man's story during the Wurm. On the left is the main glaciation, on the right the secondary phase (or "oscillation") known as the Bühl advance

MAN DURING THEn the succession of maps shows how the ice sheets advanced and the Mediterranea chart as a whole has been produced under the supervision of beginning of the Ice ure and the glacial maps are based on material in *Corridors* Palaeolithic cultures ad University Press), by H. J. Fleure and H. J. E. Peake

extensive as the previous visitation, leaving central and southern England untouched. Palaeolithic man continued to develop in this region, and in France and southern Germany, and to leave much evidence of his presence and handiwork, which would otherwise have been swept away by glacial action. But conditions were very cold, and man had to share his precarious conditions with animals well protected from the inclement weather. This is known from the remains of the hairy mammoth, woolly rhinoceros, bears, reindeer, musk ox, and numerous other species, found associated with man's weapons of offence and defence.

Forests were plentiful beyond the glacial limit, but husbandry and agriculture were impossible with such animal life in posession. So caves, forests, and river terraces sheltered man until the retreat of this great Riss period of glaciation. It was the last to visit western Europe or to extend far from the Scandinavian-Baltic area where succeeding oscillations of glacial intensity continued. The chief of these are called the Würm and the Bühl.

Würm Glacial Period

The last of these glacial periods, the Wurm, is variously estimated to have terminated in Britain from 50,000 to 10,000 years ago, although parts of Europe may still be regarded as in the retreating stage which followed the temporary Buhl advance. The cause of these glacial periods is still a matter of investigation and speculation. That a change in the elevation of the land may have caused them is one theory. Another theory is that a geographical change, such as a temporary partition of North America from South America, creating a diversion of the warm Atlantic Drift current to some other course, may have been the cause. Variations in the solar heat or the passage of the solar system through a region of extra low temperature have also been adduced as explanations. A change of tilt of the earth's axis seems a possible explanatory theory. Yet another is favoured at present—that the glacial periods were due to recurring meteorological changes which in some manner produced different areas of high and low barometric pressure, such as would result if, say, the warm cyclones of our latitudes took a more southerly course and permitted the east and Arctic winds to supplant them.

For example, Greenland is now a vast glacier-covered area in a similar latitude to that of Scandinavia, which at present enjoys a comparatively mild climate due to the prevailing warm westerly winds and sea-currents. If from some cause these winds were deflected and replaced by Arctic currents and winds similar to those prevailing in the Greenland area, one could reasonably assume a resumption of the glaciation of the past and on a great scale in north-west Europe.

The fauna and flora of northern Europe, including Britain, which was then an integral part of the European continent, assumed an Arctic character over the areas preceding the advancing glaciers. In the eastern counties of Britain are beds containing Arctic shells and fossil remains of Arctic animals. Northern and central Europe as far south as the Alps and Pyrenees was inhabited by reindeer, Arctic fox, mammoth, woolly rhinoceros, bison, hyaena, elk, cave-bear, musk-sheep, glutton, wolf, musk-ox, and boar. Remains of most of these are found in the deposits of the river valleys of England, notably the Thames.

Evidences of Interglacial Periods

Among the evidences of the interglacial periods are beds in which are found relics of quite a different fauna, one suited to a warm temperate climate. In those beds the foregoing animals give place to the elephant, hippopotamus, leopard, porcupine, African lynx, aurochs, and horses—present-day types of warmer climes, which again are superseded by creatures adapted to colder conditions.

Most remarkable of all is the development of the human species during the Quaternary era, the evidences left of their handiwork constituting so distinctive a feature that this era is usually designated the Age of Man, though man had acquired some of his human attributes in Pliocene times.

LESSON 20

The Holocene or Present Age

THE Holocene deposits belong to the age in which we live, an age sometimes called the Post-Glacial period. These deposits are almost entirely alluvial, peaty, and loess. The alluvial are usually a continuation of the Pleistocene sands and mud, brought down by the streams and deposited along the banks of rivers in the shape of terraces. They also form the beds of rivers, and spread out great deltas at their mouths, such as those of the Nile, Danube, Ganges, Euphrates, Mississippi, and Amazon. The growth of the deltaic deposits at the mouths of the Nile and Euphrates can be measured by the distance of the ports of antiquity from the present coastline. The peaty deposits include forest debris.

These are very extensive, covering wide areas in northern and central Europe and North America, and are the remains of the vast forests which grew on the rich soil left behind by the retreating glaciers after the close of the last Ice Age. The loess deposits cover extensive areas, chiefly in Asia, which are now steppe, prairie, and tundra. In these areas the fine wind-blown sand produces a state of aridity which prevents the growth of forests. Loess deposits exist in western China, reaching some 2,000 feet in thickness, and in the adobe area of North America, where they reach 3,000 feet.

Later Fossil Deposits

In all the Holocene deposits are found more or less fossilised remains of animals of the most recent or present-day species. A few of the fossilised forms have become extinct, notably the mammoth, frozen carcasses of which have been found in the ice-bound rivers and tundra of Siberia, and in the superficial alluvial deposits of central Europe and England. The big Irish deer, *Megaceros giganteus*, with antlers 11 ft. in span, has become extinct in recent, probably in historical, times. Numerous fossil remains have been found in Irish peat bogs, and in cave-earth and superficial deposits in England and Scotland, and on the European continent. Woolly rhinoceros lived until recent Holocene times; entire carcasses, covered with woolly hair, have been dug out of the frozen Siberian tundra.

As regards birds, the moas, which were exceedingly numerous in New Zealand, have vanished within the last two or three hundred years; their remains are plentiful in the superficial deposits of recent times. Remains are found in the marshes of Madagascar of a bird, *Aepyornis*, which reached 14 feet in height and produced eggs 30 inches in circumference. Another bird, one incapable of flight, the dodo, *Didus ineptus*, was last seen alive about 1680; it inhabited Mauritius, Réunion, and Rodriguez, and its remains are found in the peaty deposits of those islands. The solitaire, *Pezophaps solitarius*, related to the dodo, vanished from Rodriguez about 1760. The great auk, *Alca impennis*, became extinct in the last century, the last pair known being killed in 1844.

Turning from the geological record of the past, one can consider the forces that are moulding the earth's surface to-day, often in a manner which conflicts with man's wishes and requirements. This conflict is seen on a small scale when a few acres of farmland, or a homestead or two, vanish in a cliff-fall in a single night, as happens sometimes around the shores of England, particularly along the coasts of Norfolk, Suffolk, Sussex, and the Holderness coast of Yorkshire. Another aspect of the process is seen when rivers change their course, as, for instance, the Indus and the Hwang-ho. Mountains slip from time to time, destroying fields and houses, and even slipping hillsides can cause disaster, as in suburbs of Lyons in 1930 and again in 1932.

In addition to these catastrophic occurrences, there are *secular movements* imperceptible to the eye—movements due to silent geological forces which are ever at work, raising a sea-bed here, lowering a whole country there—processes which are evidenced by submerged forests and raised beaches respectively. Submerged forests are numerous around the shores of England and Wales, and to a lesser degree in Scotland. The wood can scarcely be regarded as fossilised, though very ancient and usually black with age and impregnation.

Submerged Forests

Submerged forests occupy a large portion of the Thames estuary, and are obviously much later than the raised river terraces of sand and gravel deposited in the Pleistocene period, in the Palaeolithic and Eolithic ages of man. Similar forests are found off the east coast, more particularly off Lincolnshire and Durham, in the estuaries of the Humber and the Wash, beneath the fenland, and off the south coast from Hastings to Torbay. In the Bristol Channel they extend far out beneath the sea, and are well in evidence in Porlock and Caermarthen bays. Abundant remains can be seen at very low water in Cardigan Bay, off the Wirral Peninsula and the coast of Lancashire, and as far north as the Solway Firth. This fall of the land has been proceeding for some thousands of years, judging from the remains of Bronze Age men found in the uppermost layers of these submerged forests, and from the Neolithic artifacts discovered in the lower layers.

BOOK LIST

Wonders of the Earth's Crust, H. E. Taylor (Pitman); *Text Book of Geology*, Sir Archibald Geikie (Macmillan); *Aids in Practical Geology*, Grenville Cole (Griffin); *Stratigraphical Geology*, J. A. Jukes-Browne (Stanford); *An Introduction to Stratigraphy*, L. D. Stamp (Murphy); *An Introduction to Palaeontology*, A. Morley Davies (Murby); *Making of the Earth*, J. W. Gregory (H.U.L.); *Rocks and Their Origins*, G. A. Cole (C.U.P.); *Volcanoes*, J. W. Tyrrell (H.U.L.); *Earthquakes and Mountains*, H. Jeffries (Methuen); *Our Mobile Earth*, R. Daly (Scribner); *Submerged Forests*, Clement Reid (C.U.P.); *The Study of Geological Maps*, G. L. Elles (C.U.P.); *British Regional Geology Handbooks* (H.M. Stationery Office).

MUSIC

THE *appreciation of good music is one of the most valuable assets that anyone can acquire. True appreciation depends on knowledge and understanding, and both are equally important for the skilled performer and the ordinary listener. This Course covers a wide field of musical knowledge. It outlines the principles of staff notation, of time and rhythm, and of elementary harmony. It describes the chief instruments of music and explains their technique and function. It traces the history of western music from the 12th century, and it ends with a short survey of musical education and the practice of music in Great Britain to-day.*

19 LESSONS

LESSON 1

Staff Notation

Any method of writing music on paper must express two things simultaneously: the pitch of each note, and its duration or the length of time it is to be sounded. In the modern method of staff notation, pitch is represented by the position of the note in a stave of five horizontal lines, duration by its shape. This method was not suddenly invented; it developed gradually from the 11th century onwards, reached something resembling its present form in the 16th century.

The basis is a stave of five lines. Notes can be placed either on a line or in a space, and a

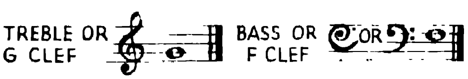


Fig. 1

sign called a clef at the beginning of each stave indicates the pitch to which they will correspond. The two common clefs are shown in Fig. 1.

The treble sign was originally a letter G, beginning on the second line from the bottom, so that a note on this line represents the G above middle C. Thus the five lines (from below up) represent E G B D F, the four spaces F A C E.

The bass sign was originally the letter F, beginning on the second line from the top and fixing this as F below middle C. So the five lines in the bass clef represent G B D F A, the four spaces A C E G.

For piano music these two staves are combined one above the other. Though for

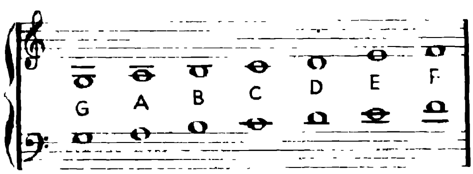


Fig. 2

convenience a wide gap is left between them, there is in fact only one line missing: the line corresponding to middle C. If this is supplied, the resulting 11 lines are called the grand stave. This grand stave was never actually used for writing music, though staves of three, four, six, and even eight lines were tried in the early days, before custom settled on five lines as the most convenient.

Alto Clef and Tenor Clef

When notes fall above or below the five lines, their exact placing is made clear to the eye by short lines, called leger lines. The examples in Fig. 2 show different ways of writing the same notes. There are two other clefs in common use: the alto clef and the tenor clef. The sign for both was originally a letter C, and the middle of the sign, which is always on a line, indicates the position of middle C. The alto clef is used in music for the viola, the tenor clef for the

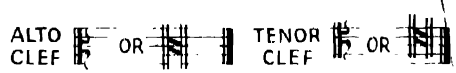


Fig. 3

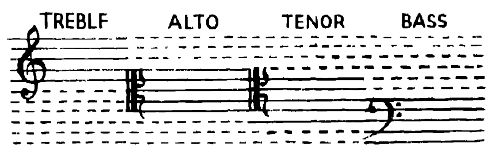


Fig. 4

higher registers of the cello, the tenor trombone, and a few other brass instruments, Fig. 3. The position of these four staves in the grand stave of 11 lines is shown in Fig. 4.

The notes produced by the white piano keys over four octaves are shown in Fig. 5. This is what is called a scale—the scale of C major. It is difficult to give in words a complete definition of a scale. Superficially, it is a series of notes in ascending or descending order, and represented by successive letters of the alphabet. In practice, the scale provides the basis or framework on which both melody and harmony are built. Two chief kinds of scale are used in western music: major scales and minor scales. Both are called diatonic. A succession of semitones such as would result in playing all the

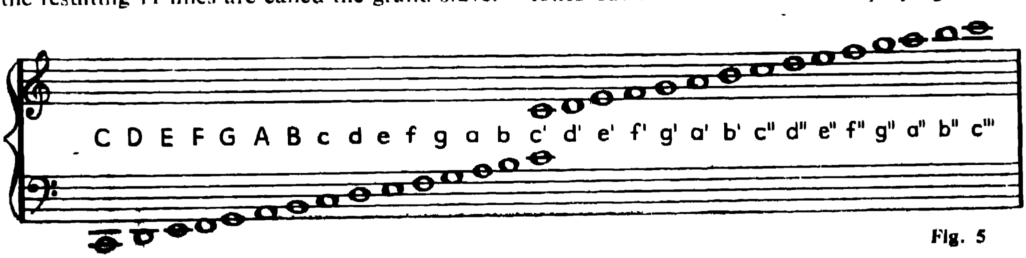


Fig. 5

notes of the piano, white and black, in order, is called a chromatic scale, and it has not the same logical effect on the mind as the diatonic scales.

The Major Scale

In the major scale the intervals between successive notes are sometimes tones, sometimes semitones. The order is : tone, tone, semitone, tone, tone, tone, semitone. Thus the semitones fall between the 3rd and 4th, and the 7th and 8th degrees ; the other intervals are all whole tones. This arrangement corresponds with the white notes on the piano beginning with C. But if one began with G, the white notes would no longer give a major scale, because the second semitone would now fall between the 6th and 7th instead of between the 7th and 8th degrees.

Fig. 6

To play a scale of G major on the piano, it is necessary to use the black note next above F (called F sharp), and this is indicated in writing by means of a sharp sign, Fig. 6.

Similarly, the scale of D major requires two sharps (F and C) ; of A major, three (F C G) ; of E major, four (F C G D) ; of B major, five (F C G D A) ; of F-sharp major, six (F C G D A E) ; of C-sharp major seven (F C G D A E B) E-sharp is the same note as F on the piano, and B sharp as C.

Any major scale beginning on F would come out right on the white notes, except that the first semitone would fall between the 4th and 5th instead of between the 3rd and 4th degrees. This time, to get it right it is necessary to play

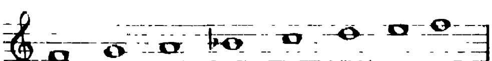


Fig. 7

the black note below the B (called B flat), and this is written with a flat sign, Fig 7. Similarly, the scale of B flat major requires two flats (B and E) ; of E flat major, three (B E A) ; of A flat major, four (B E A D); of D flat major, five (B E A D G); of G flat major, six (B E A D G C); of C flat major, seven (B E A D G C F). C flat is the same note on the piano as B ; F flat as E.

The Key Signature

The scale in which a piece of music is written is called the key, and to save having to write innumerable sharp or flat signs through the music, the correct number for the key (in the proper order) are written on the stave at the beginning of each line. These signs, called the key signature, apply to the corresponding notes all along the line, as in Fig 8.

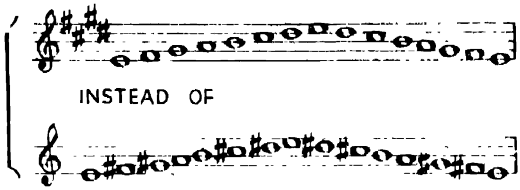


Fig. 8

Originally the minor scale corresponded to the white notes on the piano beginning with A, so that the order of intervals was : tone, semitone, tone, tone, semitone, tone, tone.

The Minor Scale

Then it was found convenient for purposes of harmony to raise the seventh degree by a semitone, leaving a leap of three semitones between the 6th and 7th degrees. This is called the harmonic minor, Fig. 9. In an alternative

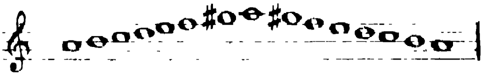


Fig. 9

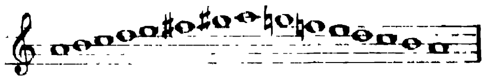


Fig. 10

form, both the 6th and 7th degrees are sharpened, but only when ascending ; in descending, the original notes are used. This is called the melodic minor, Fig. 10.

The signs for these sharpened notes are not written as part of the key signature but introduced separately as required. Note also the sign in the melodic scale which contradicts the preceding sharp : it is called a natural.

Accidentals

All sharp, flat, and natural signs introduced, apart from those of the key signature, are called accidentals. Minor scales with key notes other than A require key signatures, and in each instance the number of sharps or flats required is the same as for the major scale whose key note is the third degree in the minor scale. Thus C is the third degree in the scale of A minor ; neither C major nor A minor requires any key signature. G is the third degree in the scale of E minor, so E minor requires one sharp, like G major. That can easily be worked out with the series of tones and semitones just given. Scales with the same key signature are called relative scales—A minor is the relative minor to C major, etc. Fig. 11 is a full table of key signatures, as written in treble and bass clefs. Key notes for the minor scales are printed black.

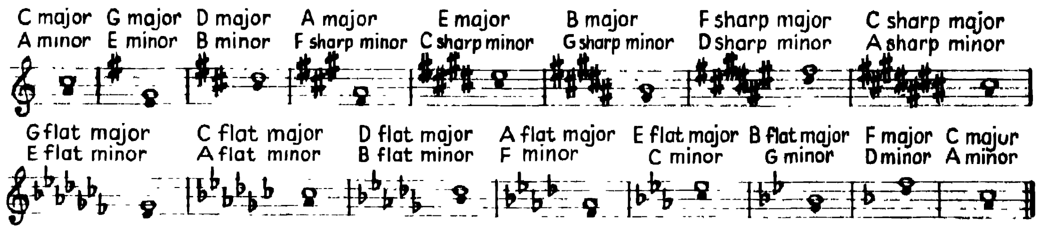


Fig. 11

The notes or degrees of any scale, major or minor, are given the following names:

8th	Octave
7th	Leading note
6th	Submediant
5th	Dominant
4th	Subdominant
3rd	Mediant
2nd	Supertonic
1st	Tonic or key note

The interval between any two notes is reckoned from below upwards, and both notes are included in the count. Thus the interval between tonic and supertonic is a second; between tonic and mediant, a third; between tonic and subdominant, a fourth; and so on. Of these, the intervals of the fourth, fifth, and octave are the same for both major and minor scales, and are called perfect; the third and sixth differ, and are called major and minor, accordingly. An interval is augmented when it is increased by a semitone, diminished when it is decreased by a semitone.

As they work out on the piano, these names overlap. Thus the interval from C to the black note between F and G is an augmented fourth if you call this note F sharp; a diminished fifth if you call it G flat. But the tuning of the piano is actually a compromise. In the true scale (or "just intonation") F sharp is slightly lower than G flat. From C to C sharp (a chromatic semitone) is a slightly smaller interval than from C to D flat (a diatonic semitone) and the minor tone (from supertonic to mediant, or from dominant to submediant) is slightly smaller than the major tone (from tonic to supertonic, subdominant to dominant, or submediant to leading note). These distinctions, though they cannot be heard on the piano, are often observed in good string playing or unaccompanied singing, and have far-reaching implications in the harmony.

From regarding (say) the note between F and G as F sharp to regarding it as G flat, the change is called enharmonic; similarly with any other switch involving notes which are written differently, though they sound the same on the piano and other keyboard instruments.

To avoid confusion, two other signs for accidentals are in use – the double sharp and the

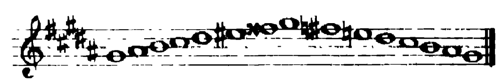


Fig. 12

double flat. The double sharp is illustrated in the scale of G sharp minor, Fig. 12. Note the single sharp with a natural sign used to contradict the double sharp. The double flat is written simply as two flat signs, and contradicted by a natural and a flat.

LESSON 2

Time, Rhythm, Dynamics, and Style

The duration of a note is indicated by its shape. Of those shown in the table, each takes half the time of the one in the row above, so that each row is performed in the same length of time, Fig. 13. Similarly, there are demisemiquavers with three tails, semidemisemiquavers, with four, and so on. Breves are now rarely found except in church music. A dot after a note makes it half as long again, so that a dotted semibreve lasts as long as three minims; a dotted minim, as three crotchets, and so on, Fig. 14.

Because it is necessary not only to know how long the sounds go on but how long the silences

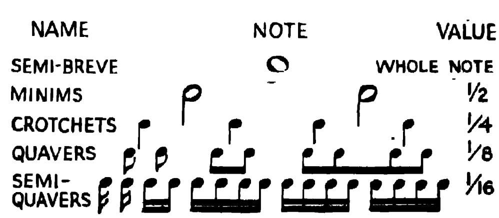


Fig. 13

Fig. 14

between them last, there are also a set of signs called rests. These, with the notes to which they correspond in length, are as in Fig. 15.

Fig. 15

The basic rhythm in which any particular piece of music is to be performed is indicated by a system of bar lines, together with a time signature, which indicates the number of beats in a bar and how the accent falls. In 3/4 time,

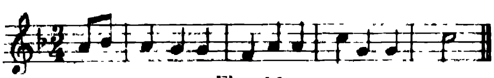


Fig. 16

there are three beats in a bar and each beat represents a $\frac{1}{4}$ note or crochet ; the accent falls regularly on the first beat in the bar. Waltzes (Fig. 16) and minuets are written in 3/4 time.

In 4/4 time (often called common time and labelled with a C) there are four crotchets to a

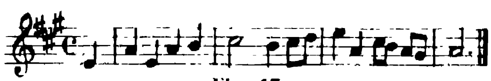


Fig. 17

bar ; the chief accent falls on the first, a somewhat weaker accent on the second, Fig. 17.

In 2/4 time there are two crotchets in a bar ; in 2/2 time two minims. Both kinds have the accent on the first beat in the bar, Fig. 18 In

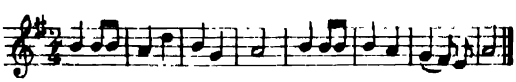


Fig. 18

6/8 time there are six quavers in the bar, with the main accent falling on the first, and secondary accent on the fourth ; this distinquishes it from 3/4 which may also have six quavers in the bar, but grouped in twos instead of threes, Fig. 19. Of other possible time signatures, 9/8, 12/8, and

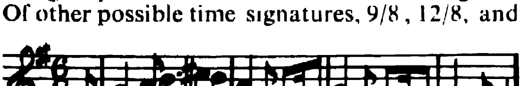


Fig. 19

12/16 are not uncommon ; 4/2 is met with chiefly in church music ; 5/8 and 7/8 are rare.

Rhythms with two beats in a bar are said to be in simple duple time ; those with six beats, compound duple. Similarly, 3/4 is simple triple time, 9/8 compound triple, 12/8 compound quadruple.

In writing music the full time duration must be filled up in each bar, either with notes or with rests. The only exceptions are the first and last bars, which may be incomplete ; but it is customary to write the last bar so that it and the first together make one complete bar.

An accent or stress on any particular note can be indicated by the sign > placed over it. A horizontal line with curved ends connecting two notes of the same pitch (called a ligature)

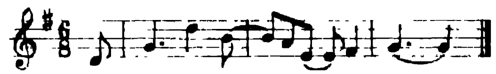


Fig. 20

indicates that the second is not sounded separately, but treated simply as a prolongation of the first, as Fig. 20.

A dot above or below a note (as distinct from after it) indicates that it must be played suddenly and sharply, and the sound allowed to stop before the next note starts. This is called *staccato*. The opposite of this—continuous sound in which each note carries smoothly into the next—is called *legato*. It may be marked by a sign which resembles a ligature but in this context is called a slur. The slur always joins two different notes : for more than two notes, longer curved lines may be used, thus giving a general indication of the phrasing.

The speed at which a piece is to be performed can be stated accurately by giving a metronome number. A metronome is a kind of inverted pendulum, driven by clockwork, which can be adjusted to oscillate and give out a loud tick from 40 to 208 times a minute. If the metronome mark is given as a minim equal to 60, it means that 60 minims should occupy one minute, so that each minim lasts just one second. Similarly, a crotchet equal to 140 would mean that a crochet is to take rather less than half a second, and so on.

Besides this exact specification, there are a number of Italian words customarily used to describe the speed or tempo at which the music should be performed. Some of these also carry implications as to the manner of performance. Chief of them are :

Largo	Slowly and weightily
Grave	Slowly and sadly
Adagio	Slowly and tenderly
Lento	Fairly slowly
Moderato	At a moderate pace
Andante	At an easy pace
Allegretto	Faster than *andante*
Allegro	Fast and lively
Vivace	Usually faster than *allegro*
Presto	Very fast
Prestissimo	Very fast indeed

To these can be added *rallentando* and *ritenute*, which both indicate a slowing off or slackening of pace, and *accelerando*, which indicates a speeding up.

Other Italian words refer to the loudness with which the music is to be played—and other points of expression. Of these the most common are:

Pianissimo ..	pp	Very soft
Piano	p	Soft
Mezzoforte ..	mf	Moderately loud
Forte	f	Loud
Fortissimo	ff	Very loud
Crescendo	cr	Getting louder
Diminuendo	dim	Getting softer
Sforzando	sf	Suddenly loud
Forte piano	fp	Loud, then suddenly soft

Many more words from Italian, or on occasion from other languages, may be used to specify style or expression. There are also directions which indicate various technicalities in the playing of particular instruments, e.g. *pizzicato* (plucking the strings), and *glissando* (sliding up or down the keys or notes); and purely practical directions like *da capo* (D.C.), which means "go back to the beginning"; and *da capo dal segno al fine*, "go back to the sign (usually 𝄋) and then finish at the word *fine*."

LESSON 3

The Principles of Harmony

The idea of enriching a single line of melody with other parts to be sung or played simultaneously can be traced back in Europe to the church music of the 10th century. The earliest examples (of a system called diaphony or organum) sound very bare to the modern ear, Fig. 21. From these simple beginnings the practice was steadily developed and elaborated, until by the end of the 18th century what is now regarded as the classical system of harmony had evolved.

Classical Harmony

For teaching purposes, classical harmony has been reduced to a series of rules and precepts which, at the elementary level at least, refer to four-part harmony of the hymn-tune type. It is true that in every generation the best composers have frequently broken the rules, trusting to the judgement of their own ears in the search for

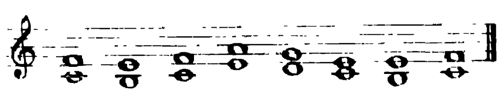


Fig. 21

new and striking effects. Sounds that seemed strange and discordant to one generation have been accepted by the next as a normal part of the language of harmony, and to-day there is hardly any collection of notes, however strident, which could not on occasion be heard together in the course of a serious musical work. Nevertheless, classical harmony is still the basis of most Western music (the only considerable exception is the music of the dodecatonic or twelve-tone school), and for that reason it still occupies a place in Western musical education.

Classical harmony has as its foundation a series of triads or chords of three notes formed on the seven degrees of the diatonic scale. In Fig. 22 they are shown in the scale of C major. Of these the first, fourth, and fifth—i.e. the chords on the tonic, subdominant, and dominant—are major triads, because they contain the major third from the bass note or root of the chord. The second, third, and sixth—i.e. the chords on the supertonic, mediant, and submediant—are minor triads. The chord on

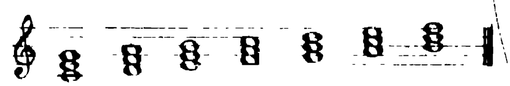


Fig. 22

the leading note is a diminished triad (on account of the diminished fifth from the root) and is technically a discord.

Since all the notes of the major scale are included in at least one of the three major triads, it is possible to harmonise any diatonic

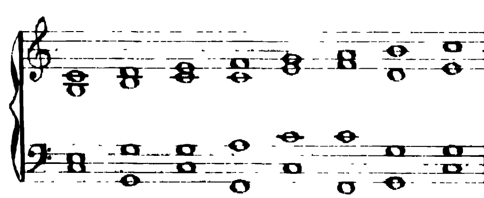


Fig. 23

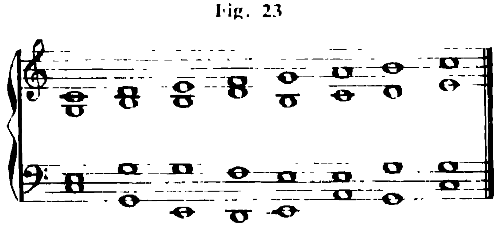


Fig. 24

melody in a major scale by using three chords only, Fig. 23. A subtler and more varied effect is obtained by introducing minor chords as well, Fig. 24.

In order to produce four parts, one of the notes of a triad has to be doubled. With the major triads it is considered best to double either the root or the fifth; rarely the third. It

is possible to omit the fifth altogether, in which case both the bass note and the third may be doubled. But if the third is omitted the chord tends to sound hollow and unsatisfactory. The rule against doubling thirds does not apply to the minor triads.

In writing for four voices it is well to keep within the compasses shown in Fig. 25. Other

Fig. 25

general rules applicable to harmonic progressions are : keep the parts together and avoid big skips ; if two consecutive chords have a note in common, keep it so, Fig. 26. Consecutive 5ths and consecutive octaves give weakness to harmony and should be avoided, Fig. 27.

Fig. 26

In these examples of consecutives the extreme parts (treble and bass) both move in the same

Fig. 27

Fig. 28

direction : this is called similar motion, and it is likely to lead to trouble. Contrary motion, Fig. 28, is more interesting, and should be used frequently.

When two parts progress by similar motion to either a fifth or an octave it has an effect similar to that of consecutive octaves or fifths ; the ear instinctively runs up the intervening notes although they are not sounded. These "hidden consecutives" should also be avoided, particularly between the extreme parts, Fig. 29

Fig. 29

Apart from the ugliness of "consecutives," the smooth sounding of harmony depends greatly upon the right disposition of the notes of any chord or, as it is called, registration. In general, it is best to keep the third of the chord high rather than low ; low thirds sound thick and muddy. There should not be any long gaps between the parts, especially between treble and alto ; it is often necessary to separate tenor and bass, to avoid similar motion between the extreme parts.

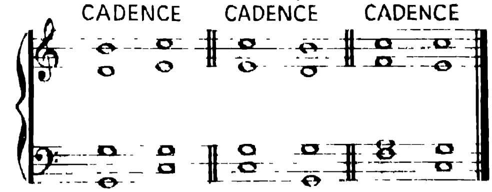


Fig. 30

The end of a musical phrase is called a cadence. There are three principal cadences : the perfect cadence or full close, consisting of the chord of the dominant followed by the chord of the tonic ; the imperfect cadence or half close, tonic followed by dominant ; the plagal cadence, subdominant followed by tonic, familiar as the "amen" of hymn tunes, Fig. 30.

Up to this point, all the common chords have been used in their original or root positions -

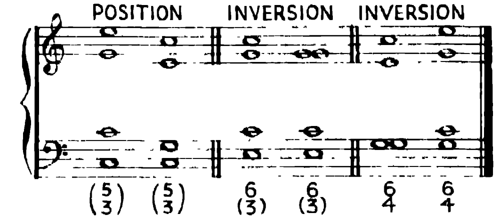


Fig. 31

having the note on which they are built in the bass. When this note is not in the bass, or lowest part, the chord is said to be inverted. Fig. 31.

The figures placed below the bass notes are a traditional way of indicating the chords used. In the 18th century the music for keyboard instruments accompanying soloists often

consisted of only a bass line with figures under it. The player had to "realize" this "figured bass" and play the full chords extempore.

In this convention the root position of a common chord is called a 5/3 chord, as it consists of the key note, its third (major or minor), and fifth. The first inversion is called a 6/3, E to G being a third, and E to C a sixth, from the bass or lowest note. As a matter of convenience, common chords in their root position are not figured at all, and in the first inversion the 3 is omitted, but the second inversion is always figured 6/4. A common chord is figured when another chord occurs on the same bass note.

In the first inversion, double the third or the sixth, as most convenient, but not the bass note.

Fig. 32

In the second inversion the 6/4 is frequently followed by a 5/3 : when this happens, make the 6 descend to 5, the 4 to 3, and double the bass note, Fig. 32. Sometimes a bass note struck twice or sustained will be figured 5/6. This means that the 5 goes to 6, while the 1 and 3 remain stationary, Fig. 33.

For many years music was made up entirely of concords. Discords came only very gradually to be tolerated. It is probable that people's

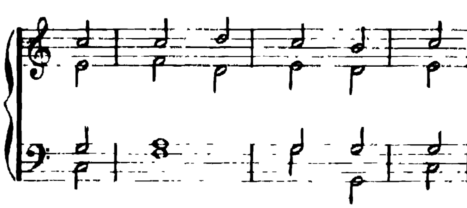


Fig. 33

ears first got used to them through hearing the effect of such devices as passing notes, suspensions, and anticipations. Passing notes are transitional notes in any one part which do not belong to the harmony. They usually fall on an unaccented beat, and form a short scale passage between one harmony note and the next. Their use adds variety, brightness, and continuity of movement to the parts, and can lighten a tendency which music has to become heavy and stilted if every note is harmonised. Examples are in Fig. 34.

A suspension occurs when one note of one chord is carried over to sound for some time

Fig. 35

simultaneously with the following chord. The commonest suspensions are : 9 to 8 (i.e. the ninth of the new bass eventually changing to the octave), 6 to 5, and 4 to 3, Fig. 35.

Anticipations are the opposite of suspensions —sounding one note of the new chord while the

Fig. 36

old chord still continues in the other parts. The best known example is in the typical Handel cadence, Fig. 36.

One of the commonest passing notes used in the early days was the fourth of the scale between dominant and mediant in a perfect cadence. From this to incorporating the passing note into the chord of the dominant is a very natural step, Fig. 37. The new chord is called the dominant seventh, and is technically a discord ; it is felt to be incomplete in itself, requiring some particular concord (here the chord of the tonic) to follow it and " realize " the discord.

As there are four notes in the chord of the dominant seventh, there-are four positions—

Fig. 34

Fig. 37

the root position shown in Fig. 37, and three inversions. All these contain a discord, which requires to be resolved, usually on the chord of the tonic. In moving to the resolution the

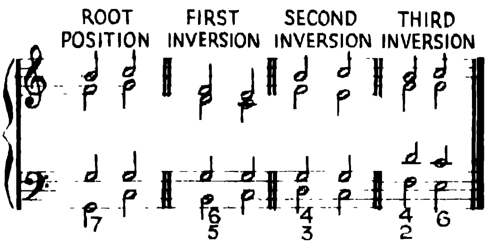


Fig. 38

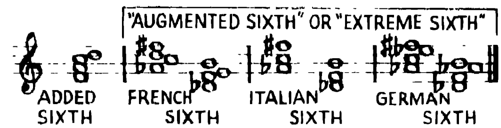


Fig. 39

seventh of the chord should always rise, the third descend, Fig. 38. Further examples of discords with their traditional resolutions are shown in Fig. 39.

Few compositions, however short, remain in one key throughout, and the process of moving from one key to another is called modulation. The modulations most frequently introduced are those by which the music is taken into the keys of the dominant or subdominant, as from C to G, or C to F. Such modulations can all be brought about by changes in, or additions to, one or other of the chords of the original key.

For example, take a modulation to the subdominant, as at (a) in Fig. 40. Here you have simply to add a minor seventh to the tonic, which later thus becomes the dominant of a new scale, the scale of F. Again, at (b) a modulation

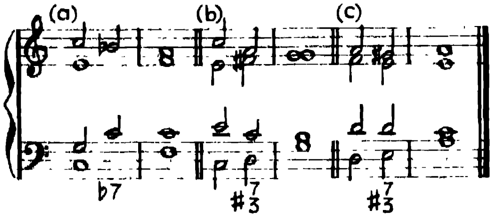


Fig. 40

to the dominant is easily and naturally effected by making the third of the chord of the supertonic of the original scale a major third, and adding a seventh to it. Once more, you can modulate into the relative minor, as at (c), by making the third of the chord of the mediant a major third, and adding to it a seventh.

It is in this way, by means of the chord of the dominant seventh, that the majority of modulations, at least to closely related keys, are managed ; and the surest way to establish the tonality of a new key is to introduce its dominant seventh and resolve it on the new tonic.

Another well-known chord, capable of effecting modulations to more remote keys, is the

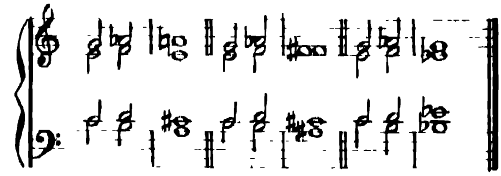


Fig. 41

chord of the diminished seventh, which can be derived from the triad on the leading note by adding another minor third above it, Fig. 41. It is a convenient chord almost too convenient —and should be used with discretion.

The repetition of any short passage of melody or harmony, each part moving by the same degrees as the original passage, is called a

Fig. 42

sequence, of which there are two kinds ; tonal, when it remains in the same key throughout ; real, when the key changes, Fig. 42.

A false relation is the separation of two chromatic notes, by giving one of them to one part and the other to another part as at (a) in Fig. 43. If the chromatic notes both occur in

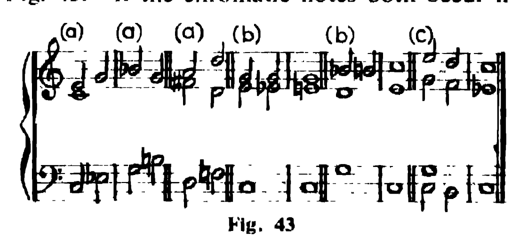


Fig. 43

the same part, the bad effect is avoided, as at (b). A false relation may be heard, even when separated by a chord, as at (c).

LESSON 4

Form in Music

All good melodies have some sort of shape or form. The simplest melodic shape consists of two sections, A and B, which are sometimes likened to question and answer, or statement and reply. This shape, AB, is called binary form. Well-known examples are "Little Brown Jug"; "Good-Night Ladies"; and "Camptown Races."

Often there is a third section which repeats (or nearly repeats) the first to produce ternary form, ABA, or sometimes with an additional repetition, AABA. In either case there is usually a subtle difference compared with binary form, for in ternary form the middle (B) section is more apt to give the impression of a commentary on the first, than of a complete reply to it. Well-known tunes in ternary form are "Drink To Me Only With Thine Eyes"; "John Peel"; and "Auld Lang Syne."

Not infrequently in ternary form, the middle section modulates into a different key from the first and last section - the commonest change being to the key of the dominant. Typical examples are "The Vicar of Bray," and "The Old Folks at Home."

On a Larger Scale

Binary and ternary forms are also used to give shape to whole pieces of music. For instance, the minuet, which was commonly used as the second movement in early sonatas and symphonies, was almost always in ternary form, the middle or B section being called a trio. When later composers speeded up the minuet, and occasionally added cross rhythms or syncopations to enliven it, they called it a *scherzo* or joke, but it remained typically in ternary form.

An extension of ternary form is the *rondo*, in which the original tune A is alternated with several contrasting tunes or sections in the form A B A C A, etc. The *rondo* was at one time a favourite form for the last movement of a sonata or symphony.

Sonata Form

The sonata form was commonly used in classical music for the first movements of sonatas, symphonies, concertos, string quartets, etc. It is also an elaboration of ternary form. It begins with the main tune—called the first subject—which may then be repeated to establish it more clearly on the mind. This is followed by a contrasting tune or second subject in a different key—usually the key of the dominant.

The whole is then repeated; and a firm cadence marks the end of the first section, called the enunciation. There follows the development, in which the material sometimes of the first subject, sometimes of the second, sometimes of both, is taken up and varied, presented in new keys and new combinations and worked up to a climax. After that comes the recapitulation, presenting the first subject again in its original form, followed by the second subject, this time in the key of the tonic.

That is a bare outline of the traditional form. In practice there were (and are) many variations. An arresting introduction often preceded the entry of the first subject, and the recapitulation proper was frequently followed by a *coda* or tailpiece to give a more satisfying conclusion. The structure was emphasised throughout by the use of different keys to contrast and relate the various sections, and this is the fundamental principle of the sonata form. But composers were constantly experimenting with fresh relationships among the keys used, and with fresh devices for unifying the whole structure.

Variations

Another form frequently used for slow movements and sometimes for the finale in symphonies and sonatas, is the theme with variations. At first the variations were little more than decorations of the original tune. Later they became more subtle, taking the form of new music developing the original theme, or simply built on the same harmonic pattern. Among famous sets of variations are Bach's "Goldberg Variations" for harpsichord, Beethoven's "Diabelli Variations" for piano, and Elgar's "Enigma Variations" for orchestra.

Closely related to the variation form is the ground bass, in which a comparatively short bass figure is steadily repeated throughout the music, and the other parts built in constantly varying patterns on it. The *chaconne* was a slow dance form built on a ground bass; the *passacaglia* a very similar form, in which, however, the theme of the ground might pass from the bass to other parts.

Dance Forms

Dance forms have always been an important element in music, and both before and after the invention of the symphony suites, consisting of a succession of dance forms, were popular. The best known of the earlier dance forms were the minuet, in 3/4 time but slower than a waltz; the gavotte and the bourrée, French dances in lively 4/4 time; the sarabande, a slow and stately Spanish dance in 3/4 time; the gigue, a fast Italian dance in some form of triple time; and the Siciliana, a Sicilian dance usually in 6/8 time. The allemande, found in

many old suites, was generally a highly ornamented melody in 4/4 time, but seems to have had no relation to any dance of that name.

The custom of using dance forms did not die out with the 18th century. Besides innumerable waltzes, 19th century composers wrote polkas, mazurkas, schottisches, and polonaises ; and to-day ragtimes, foxtrots, tangos, and boleros still occasionally creep into quite serious music.

Contrapuntal Forms

The forms so far mentioned are based either on the themes and harmony (like the sonata) or on rhythm (like the dances). In the earlier days another basis for form was found in counterpoint. This is the weaving of two melodies together. Its interest is in the horizontal movement of the separate parts, whereas harmony is concerned with the vertical relations of the notes and the progression of chords as a whole. Naturally, in weaving tunes together, it makes for unity of feeling if all the tunes are more or less alike—i.e. if one part imitates another. Imitation, therefore, is the basic device in counterpoint.

The simplest of the contrapuntal forms is the canon, in which one part begins later but imitates its predecessor exactly, either on the same notes or at any interval above or below. A common form of canon is the round. Most people know "Three Blind Mice," and "Frère Jacques." The oldest known example (13th century) is "Sumer is i-cumen in," and it ranks as the best piece of medieval music which has come down to us. It is in six parts, of which the top four sing a round, the bottom two a double ground bass in canon.

The most important of all the contrapuntal forms is the fugue. A fugue is hard to describe in detail, because there are so many variations of the basic pattern. The usual number of voices (or parts) is three or four, but there can be as few as two, and there is no upper limit to the number. The subject is usually announced on one voice alone ; then a second voice gives the "answer," while the first continues in counterpoint. The answer may be the same theme as the subject a fifth or a fourth away, or it may be a variation or a complement to it, like the second section of a ternary tune.

Other voices then enter with subject and answer successively ; and when every voice has said its say, and the subject has been stated sufficiently often to be firmly impressed on the mind, the first part or exposition of the fugue is complete. Sometimes in course of it, the part given to the first voice while the second voice is enunciating the answer is destined to be important later ; if so, this is called the "counter subject."

Second Section of a Fugue

In the second section of a fugue, subject, answer, and counter-subject (if there is one) are developed in the different voices in various keys and various relations to each other, until they arrive at a climax in the third section, which is frequently (but by no means always) achieved by a hurrying-up arrangement called a *stretto*.

This description of a fugue makes it appear to some extent to resemble the sonata, with its enunciation, development, and recapitulation. But the resemblance is little more than the general similarity of all ternary forms represented by A B A. The distinctive thing about a fugue is the discussion of a single theme by various contrasted voices. Bach was the greatest writer of fugues ; but the form was also used for very different purposes, by Scarlatti, Handel, Mozart, and Beethoven.

LESSON 5

The Physical Basis of Music

SOUND is a form of wave motion in the air, and in musical sounds the waves are comparatively regular. Their frequency (i.e. the number of waves which pass any given point in a second) is recognized by the ear as what is called "pitch."

Since 1939 the standard pitch for concert performance in Great Britain (British Standard Concert Pitch) has been one which gives A′ (above middle C) a frequency of 440 cycles (or complete waves) per second ; and this specification was accepted by the International Standards Organization in 1955. During the 19th century concert pitch was much higher (A′= 452.5 c/s), and this old concert pitch, or something like it, is still frequently used in brass bands. But in the 18th century the pitch was a good deal lower than it is to-day ; so that Handel and Bach, Mozart and Beethoven expected their music to be played about a semitone below what is now customary. This is small consolation for sopranos who find the sustained high G's of the "Hallelujah" Chorus something of a strain.

Harmonics

When a stretched string is plucked, it can vibrate both as a whole and in parts or sections each of which is a simple fraction of the whole. This is true also when a column of air is set in vibration, as in organ pipes and other wind instruments. The first seven modes of

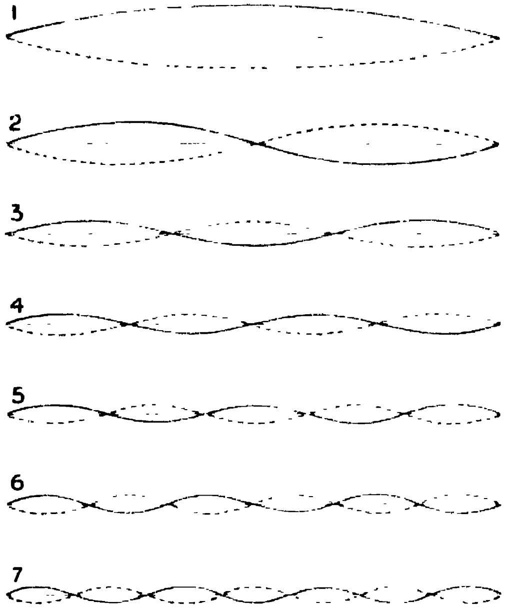


Fig. 44

vibration are shown in Fig. 44. Vibration of the whole string or air column produces the fundamental or first harmonic, which is recognized by the ear as the pitch of the note heard. The second mode of vibration (in halves) produces the second harmonic or first partial, which is the octave of the fundamental. The third harmonic is a fifth above that (i.e. a twelfth above the fundamental), and so on. The first 21 harmonics for low C are given below in staff notation. But some of these notes are only approximations. The 7th harmonic, in particular, is sharper than B flat, though still a good deal flatter than B natural ; in fact, it is much

Fig. 45

more nearly the seventh of the scale as played on a highland bagpipe. The eleventh and thirteenth harmonics also fall between the notes of the normal piano scales, Fig. 45.

A sound which consists of a fundamental alone, without any other harmonics, is called a pure tone. Genuine pure tones are very rarely heard : probably the nearest commonly met with are the note of a tuning fork, or the sound made by blowing across the mouth of a bottle. For test purposes, a steady pure tone at a pitch of A = 440 c/s is broadcast every day by the BBC just before the opening of the Third Programme. It is curiously unpleasant to listen to for any length of time.

In practice, musical notes are mixtures of a fundamental tone (giving the pitch) and a number of other harmonics at various intensities. It is the pattern of the harmonics which gives the sound its peculiar quality or timbre, so that one can tell whether it is coming from a violin, a flute, a trumpet, a saxophone, or a singer. Brilliant instruments like the violin produce a large number of fairly strong high harmonics ; in mellow instruments like the flute they are relatively few and weak.

Consonance and Dissonance

When two different pure tones are sounded together, one of two things may happen. If the wavelengths of the one fit evenly into the wavelengths of the other, the two sounds merge smoothly into a single combined tone. This is illustrated in Fig. 46, where one wavelength is half as long again as the other, so that one tone is a fifth below the other.

If the two wavelengths do not fit into each other, there will be times when the two waves reinforce each other, and times when they cancel each other out. The result is a series of beats, Fig. 47.

Beats tend to sound harsh and unpleasant, which is the basis of the musical distinction between consonance and dissonance. With pure tones in the neighbourhood of middle C, the beats are at their harshest when the two notes producing them are about a semitone apart. The harshness disappears when the notes are a minor third apart.

With the compound notes produced by most musical instruments the situation is much more complicated, because beats can arise not only between the fundamentals, but between any two harmonics which may be present. Thus a minor third on a piano or a violin is noticeably less smooth and consonant than a major third

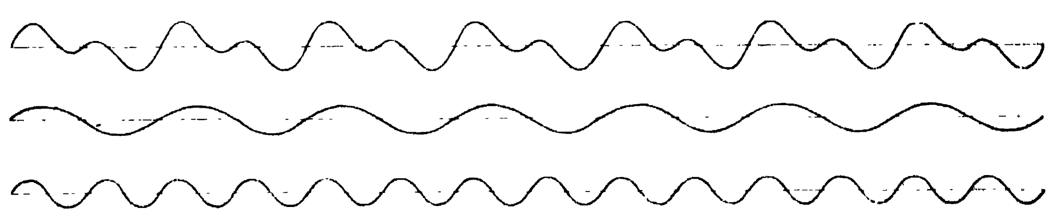


Fig. 46

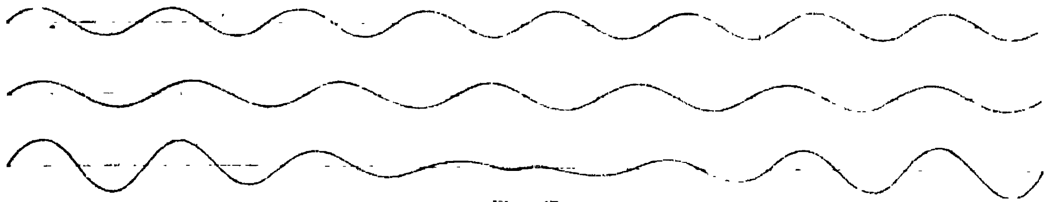


Fig. 47

or a fifth. When three or more notes are sounded together in a chord, these complications are increased enormously, so that a detailed mathematical analysis is no longer practicable. But their effect can still be appreciated by the ear, and it is reflected both in the elaborate rules of classical harmony and in the subtleties of modern orchestration.

The notes of the major scale are not just arbitrary. They were arrived at over the centuries by generations of singers and players, instinctively seeking the most consonant intervals for their melodies and chords. The fifth, fourth, and third of the scale (dominant, subdominant, and mediant) will be those notes whose frequencies are respectively $1\frac{1}{2}$, $1\frac{1}{3}$, and $1\frac{1}{4}$ times the frequency of the tonic or key-note; that is, the ratios of their frequencies to the frequency of the tonic are 3/2, 4/3, and 5/4. The other notes of the scale can then be arrived at by choosing a fifth and a third (measured by the same ratios) above the dominant, and a third above the subdominant. The result, for a keynote with a frequency of 240 (which is almost exactly the B natural immediately below middle C on a modern piano), is set out in the accompanying table. This gives also the intervals between successive notes, and shows that in the natural (or "just intonation") there are two kinds of whole tones: a major tone with a frequency ratio of 9/8, a minor tone with a frequency ratio of 10/9.

Natural scale in B = 240

Degree	Notes	Frequency	Interval	Ratio
1	Tonic	240		
			Major tone	9/8
2	Supertonic	270		
			Minor tone	10/9
3	Mediant	300		
			Diatonic semitone	16/15
4	Subdominant	320		
			Major tone	9/8
5	Dominant	360		
			Minor tone	10/9
6	Submediant	400		
			Major tone	9/8
7	Leading note	450		
			Diatonic semitone	16/15
8	Octave	480		

The natural scale works perfectly well as long as one keeps to tonic, dominant, and subdominant triads, and the minor triad on the submediant. The chord of the supertonic, however, is hopelessly out of tune. A natural minor triad on the supertonic would have the frequencies 270, 324, 405; whereas the actual notes in the scale are 270, 320, 400. These differences are altogether too great for the ear to accept; so some modification of the natural scale is necessary in any but the simplest music.

With unaccompanied singers, or stringed instruments of the violin family, the difficulty can be overcome, up to a point, by variation of pitch whenever the harmonies move into the dominant or supertonic. But this continuous and instinctive adjustment is impossible on a keyboard instrument with fixed tuning. Hence the need for the kind of compromise in the tuning of scales which is called temperament.

The earliest of these compromises was called "mean-tone temperament." In this, the difference between major and minor tones was split, and the fifth tuned slightly narrow. Thirds remained just; and all went remarkably sweetly provided the music kept within fairly closely related keys. But if it started modulating into remote keys, an unpleasant sound called "the wolf" was produced.

To make unrestricted modulation possible, "equal temperament" was invented in the 18th century (perhaps even earlier), and it is now almost universal for keyboard instruments. In equal temperament, the octaves are tuned true, and then divided into 12 equal semitones. As a result, every interval except the octaves is slightly out of true. All chords are a little harsher than the best in mean-tone temperament. It is possible to modulate from any key to any other key in either direction, and a series of 12 similar modulations will bring one round again to the original key.

Most keyboard music of the 17th and 18th centuries was written for instruments tuned to the mean-tone temperament. The change is often credited to Bach, who is supposed to have championed the new equal temperament, and to have written his 48 preludes and fugues (two each in all the 12 major and 12 minor keys) to demonstrate its advantages. But there is doubt about this. The title of the 48 is usually translated as "The Well-tempered Keyboard." It could just as easily have meant "The Well-tuned Keyboard." Bach's favourite instrument was the clavichord, and he may have intended to give his pupils practice in the frequent re-tuning which would be necessary to play all the 24 keys in mean-tone temperament.

LESSON 6

The Pianoforte

THE earliest known pianos were built by Bartolommeo Cristofori (1665 1731), a harpsichord maker in Padua and Florence, in the early part of the 18th century. Instead of the quills which plucked the strings on a harpsichord, it had hammers which struck the strings when the keys were played. As a result, the loudness of the sounds now depended on the force with which the keys were depressed. This gave the new instrument its name: "forte-piano" or "pianoforte," because it could play both loud and soft.

Fig. 48 shows the keyboard of a modern grand piano. It has a compass of seven octaves and a minor third. Upright or cottage pianos have usually a slightly shorter compass, of just seven octaves. On either instrument middle C is the white note lying immediately to the left of the pair of black keys nearest the centre of the keyboard. From there up and down, the white keys give the scale of C major: the black keys, the intervening semitones. This arrangement holds good for other keyboard instruments, such as organ and piano accordion.

Construction

The "strings" which produce the sound on a piano are, in fact, made of wire. Over most of the seven octaves, three are tuned in unison for each note. For a stretch in the bass there are two, and in the extreme bass one only. The lower wires also are overspun with soft (usually copper) wire to make them heavier, and so improve the tone of the lower notes.

When a key is depressed, two things happen: (1) the damper (a felt pad) is lifted from the corresponding strings; (2) the strings are hit by a hammer, which immediately falls back again, leaving them to sound. As long as the key remains down, the note continues to sound, though the sound is a steadily dying one. When the key is released, the damper falls back on to the strings, and the note ceases to sound.

The whole system of levers and hammers which intervene between key and string is called the "action." In modern instruments it is fairly complicated. The drawings show the mechanism for one note in a grand piano and in an upright piano. The principles are the same in both: the differences are due to the fact that in a grand piano hammers and dampers must move up and down, whereas in an upright piano they have to move horizontally.

The Pedals

In both systems the hammer travels the last inch or two to the string under its own momentum. At the moment when it strikes the string, it is no longer being pushed by the key. You can feel this from the keyboard; for if a key is pressed down slowly and gently enough, the hammer fails to reach the string, and no sound results. But the damper has been removed and the string is consequently free to vibrate, and the playing of other notes will set it vibrating. The strongest effect is obtained by playing the octave below; but it can still be heard if a note an octave and a fifth below is played, or the octave above; sometimes even with more remote harmonics. This effect is called "sympathetic" vibration, or vibration "in sympathy" with the notes that were actually played.

Most pianos have two pedals, often (quite wrongly) called the "loud" and the "soft" pedals. The right-foot pedal is, correctly speaking, a sustaining pedal. When it is down, all the dampers are simultaneously removed from all the strings. This has two consequences: (1) every note, once played, continues sounding even though the key has been released, so that up to a point the noise produced is cumulative; (2) numerous strings not actually struck start vibrating in sympathy with the strings which are struck, thus altering very markedly the tone-quality of the notes. This change in quality is just as effective when playing *pianissimo* as in the louder passages.

The left-foot pedal on a grand piano carries the whole keyboard, and the whole of the action with it, to the left. As a result, the hammers now strike only two of the strings which produce each note. The third string, though not struck, vibrates in sympathy. Once more there is a complete change in tone quality. In early 19th-century pianos, only one string was struck; and the use of the left-foot pedal is therefore indicated in Beethoven's music by the direction *una corda*, meaning "one string."

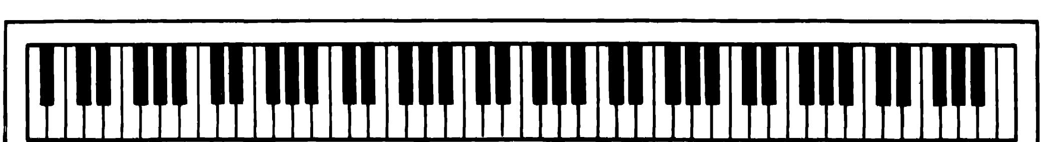
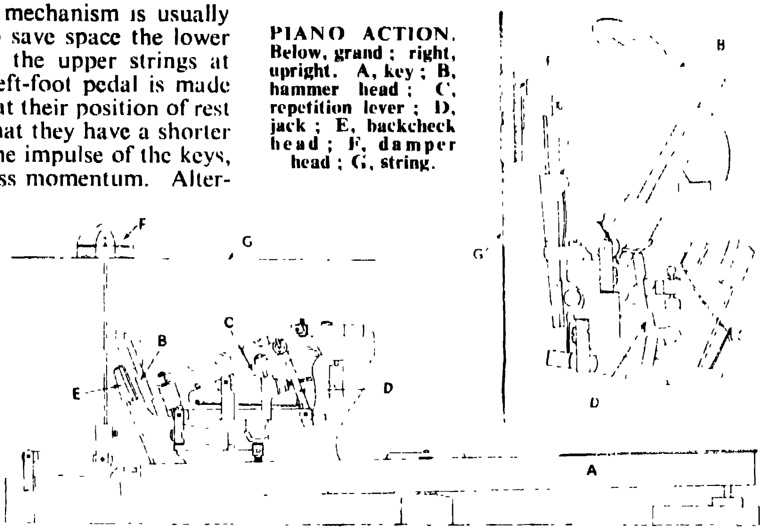


Fig. 48. THE KEYBOARD of a modern grand piano

In upright pianos this mechanism is usually impracticable, because to save space the lower strings are strung across the upper strings at an angle. Instead, the left-foot pedal is made to bring all the hammers at their position of rest closer to the strings, so that they have a shorter distance to move under the impulse of the keys, and so tend to acquire less momentum. Alternatively, the left-foot pedal may interpose a thin strip of felt between the hammers and the strings, so as to produce a softer and more muffled tone.



PIANO ACTION. Below, grand; right, upright. A, key; B, hammer head; C, repetition lever; D, jack; E, backcheck head; F, damper head; G, string.

The earlier keyboard music (which was written for clavichord or harpsichord) calls for very little, if any, use of the pedal when played on a piano. This is true of nearly all Bach and Handel, and most of Haydn and Mozart. From Beethoven onwards 19th and 20th century composers have relied on the pedals, particularly the sustaining pedal, and their music cannot be adequately performed without them.

A few modern pianos have a third pedal, the effect of which is to sustain those notes, and those notes only, which were actually sounding when the pedal was put down This is sometimes a convenience, though rarely a necessity.

The great advantage of the piano is that it enables a single player to play in full harmony, and to sustain a number of simultaneous parts in counterpoint. It is thus complete in itself, and can be used as a genuine solo instrument, or as an accompaniment to other instruments or to the voice. But it is a peculiarity of piano tone that it does not blend easily with other instruments. When playing with strings, for example, the piano is always in contrast with the string tone, whereas the harpsichord blends with the strings, and is heard chiefly as a heightening of the attack and an increased brilliance.

The piano also has less clarity than the harpsichord or the clavichord in counterpoint. But it has much more sonority in passages of chiefly harmonic interest, much more ability to sustain a singing tone, much more versatility, and much more power.

LESSON 7

The Organ

THE organ is unique among musical instruments both for the variety and for the volume of sound it puts at the disposal of a single player. This has become possible through the development of a large amount of complicated mechanism which intervenes between the player's movements and the final production of the sound. The inevitable result is a loss in the sensitiveness of the response; and if the organ remains at once the most powerful and the most various of musical instruments, it is also one of the least subtle.

The Pipes

Organs were known at least in late classical times, but not much information is available about these ancient instruments. In the Middle Ages there seem to have been three kinds of organ . a large but clumsy church organ with keys sometimes three inches wide that required the thud of a whole fist to move them; a medium-sized instrument, called a positive; and a portative organ which was carried on a strap across the shoulder, like an accordion.

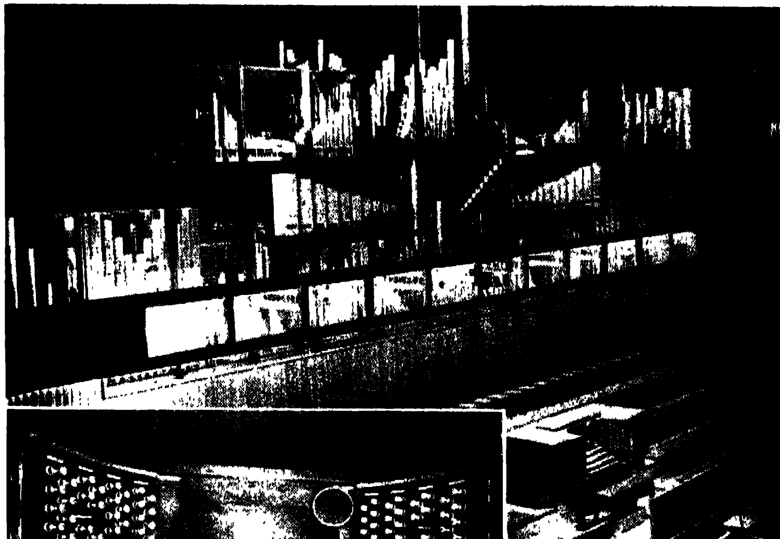
The portative organ fell out of fashion during the Renaissance, but the mechanism of the larger organs was improved, and developed into the baroque organs of the 17th and 18th centuries. These were comparatively simple instruments; but they often had a balance and clarity of tone much more suitable for contrapuntal music (such as Bach wrote for them) than the much larger, more elaborate, and cruder instruments of the 19th century.

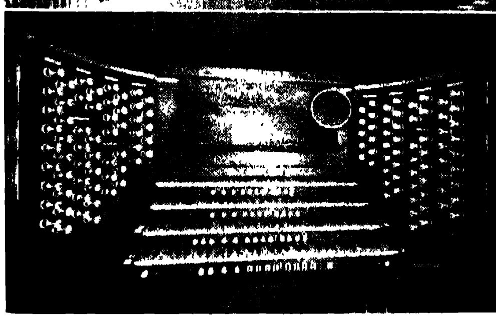
There are two main classes of organ pipe: flue pipes, which work on the principle of a

penny-whistle or recorder; and reed pipes, which have a vibrating tongue of metal somewhat resembling a clarinet reed. There are also diaphones which have a special kind of vibrating valve and are used chiefly for notes of low pitch. Pipes can be either open at the top, or "stopped," i.e. closed with a plug. Stopped pipes need be only half the length of the corresponding open pipes to yield the same note.

The main flue pipes of an organ are called diapasons, and are responsible for what one thinks of as the characteristic organ tone. Open diapasons are usually louder and more brilliant than stopped diapasons, which are round and mellow in tone. Thinner flue pipes can be mellower still, giving a flute-like effect. Other factors influencing the timbre are the material of which the pipe is made (wood or metal); the shape of the bore (round, square, oblong, triangular, cylindrical, or tapering, etc.); the shape of the slit (called the wind-way) which directs the wind against the edge where the sound is formed; and the profile of the plate (called the "language") which forms the inner boundary of the wind-way. In reed pipes the timbre is affected by the size of the pipe, by the shape of the reed, and by the shape of the opening against which it vibrates.

The largest organ pipe in England sounds the bottom note of a 32-ft. stop on the pedal organ in Liverpool Cathedral. It is 36 ft. long, 2 ft. 9 in. wide, and 3 ft. deep. There are reed pipes 64 ft. long in Sydney Town Hall and in the Municipal Auditorium, Atlantic City, New Jersey, U.S.A. The smallest pipes commonly used have a speaking length of about $\frac{3}{4}$ in., but pipes $\frac{3}{8}$ in. long are not unknown.





ORGAN in London's Royal Festival Hall. It has 4 manuals, some 8,000 pipes, 103 speaking stops, and 20 couplers. Left, the console.

Stops or Registers

A set of pipes forming a chromatic scale (usually of about 58 notes or just under 5 octaves) is called a stop or register. All the registers connected to a given keyboard form a separate "organ" or department. Of these there may be anything up to six: the great, the swell, the choir, the solo organ, the echo organ and the pedal organ. Keyboards for the hands are usually called manuals.

Traditionally, the loudest stops with most of the diapason tone are included in the great organ. The swell has a preponderance of reeds, and is enclosed in a box with shutters which can be opened or shut to provide the crescendo and diminuendo. The choir is made up of softer registers suitable for accompanying voices, and the solo largely of stops which imitate various orchestral instruments, such as viola, flute, oboe, clarinet, and cor anglais. The echo organ, where it exists, is placed at a distance from the other departments so that it can answer them antiphonally.

Pitch of a Register

The pitch of a register is usually specified by the length of an open diapason pipe which would give its bottom C. On this principle an 8-ft. stop sounds at the same pitch as a piano, a 16-ft. stop an octave below, a 32-ft. stop two octaves below. Similarly, a 4-ft. stop sounds an octave, and a 2-ft. stop two octaves, above the piano. There are also imitation stops a fifth or a twelfth above the foundation pitch (5 and $2\frac{2}{3}$ ft. respectively) which are used to add colour; and mixtures, in which anything from five to twelve pipes speak together, to provide the harmonies required for a particular timbre. Baroque organs were particularly rich in

mixtures, and there has been a revival of interest in these stops in mid-20th century.

Since the application of electricity to the mechanism of the organ, there has also been a great increase in the use of couplers, which can bring the registers of one department under the control of the keyboard of another, either at their usual pitch, or an octave above or an octave below, etc. The total result of all these devices is that one finger on one key can cause a large number of pipes to sound at different pitches, so that a simple chord can be extended far beyond the stretch of two hands on a piano. This is the characteristic organ effect. Well managed, it produces a richness and a noble sonority unapproached by any other solo instrument. Used indiscriminately, it results in a thickness and muddiness of texture which can become unintelligible and unpleasant.

Electric Systems

The application of electricity to the mechanism of the organ has had two great advantages. Electrically driven bellows or fans can give a smoother and steadier supply of wind; and electrical connections between keys and pipes make it possible to play any number of stops simultaneously with the lightest of touches. The console can be placed at any convenient distance from the pipes, or even moved about. And arrangements for bringing in or cutting out registers, singly or in pre-selected combinations, and for coupling any register to any manual, are merely a matter of wiring. An up-to-date organ has small rockers that can be flicked over with a touch of the fingers, instead of the old, heavy draw-stops to pull, with minute lights to show what registers are in use—white for flue stops, red for reeds, green for couplers.

A really big organ can be an astonishingly large piece of mechanism. That in the Municipal Auditorium at Atlantic City has over 33,000 pipes, ranging in size from ¼ in. to 64 ft., and making up 455 ranks. There are seven manuals and 1,250 stop tablets. Beside this the instrument in the Royal Festival Hall, London, is modest. It has 4 manuals, some 8,000 pipes, 103 speaking stops, and 20 couplers. But it is specially arranged, by means of an unusually large number of mutation stops and mixtures, to give a rich and varied ensemble; and it has much of the clarity in contrapuntal music of the old baroque organs.

Cinema Organs

The invention of moving pictures led to a modification of the pipe organ for use in cinemas, first to accompany silent films, then as an interlude between talking films. These cinema or theatre organs have usually many fewer individual pipes than the big church or concert organs, and rely on the great flexibility obtainable by electric wiring to provide a considerable variety of tone. They have hardly any diapason stops, but a large number of distinctive solo registers. The organ-makers call them "juicy" instruments.

They are also provided with a very considerable range of percussion sounds—drums of all kinds, cymbals, triangle, bells, tambourine, gourd, and wood block; subsidiary instruments such as piano, harp, glockenspiel, celesta, vibraphone, marimba, xylophone, carillon, and resonating gongs; and sound effects (or "traps") such as wind, surf, rain, hail, aeroplane, bird-call, police whistle, train whistle, steam whistle, siren, fire gong, klaxon horn, sleigh bells, chimes, and crockery smash. Generally speaking, cinema organs are admirable instruments. The trouble is the bad music which they are so often required to play.

Electronic Organs

The name "electronic organ," though it is used by the makers, is somewhat misleading. Electronic organs make use of amplifiers, which are ultimately electronic devices; but this is incidental. The distinctive principle is that the wave-forms which determine pitch and timbre in each note are built up in the first place as fluctuations of current in an electric circuit, and afterwards are translated into sound waves by means of a loudspeaker. It is better, therefore, to call them electrophones, or electrophonic organs. Of the two chief British makes, one generates pure tones by an electro-magnetic device, and then mixes them in varying proportions to provide different timbres for different stops. The other generates the waves electrostatically, and the harmonics are, so to speak, pre-mixed. Both have keyboards, stop-tablets, couplers, etc., as in the console of a pipe organ, and the electrostatic instrument in particular is remarkably successful in imitating the tone of a real pipe organ in a very small fraction of the space.

Harmonium and American Organs

The harmonium was invented in France about 1840. It usually has one keyboard, and the sounds are made by the blowing of air through free reeds (as in a mouth organ), instead of beating reeds, as in the clarinet or pipe organ. The bellows are worked by the player's feet, and there is an "expression stop" which makes the loudness of the music depend on the strength of the blowing. Alternatively, crescendo and diminuendo can be produced by the use of knee swells. Usually several stops are available, and they may be different for the treble and the bass parts of the keyboard.

The American organ is similar to the harmonium, but air is sucked through the reeds instead of being blown, and the tone is softer.

LESSON 8

Strings and Woodwind

THE instruments of the violin family form the acknowledged basis of the modern symphony orchestra. By themselves, as a string orchestra, they provide an extremely expressive and satisfactory medium ; and the group of four which make up the "string quartet" is held by many people to provide the purest of all forms of classical music.

All these instruments are built on roughly the same pattern. The notes are produced by the drawing of a bow of horsehair, made sticky with rosin, against the stretched strings. The sound initiated by the vibration of the strings is then amplified by a sympathetic vibration both of the body of the instrument and of the air contained inside it. The pitch is controlled by pressing the strings against an ebony board with the finger tips of the left hand, so as to shorten the length which vibrates.

Distinctive Features

The distinctive features of the whole family include a slightly arched shape for both back and belly, four strings supported by a steeply arched bridge, a sound-post wedged between back and belly immediately under the right (treble) foot of the bridge, a bass bar glued to the inside surface of the belly and running longways of the instrument under the left foot of the bridge, square shoulders, *f*-shaped sound-holes, and no frets.

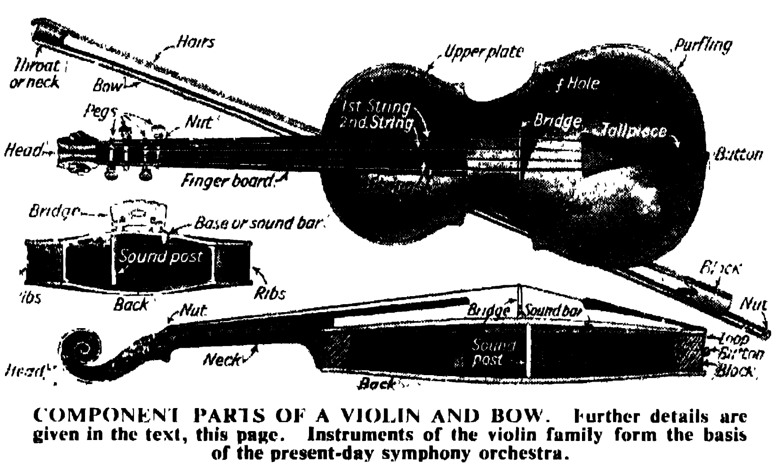
The bow is made so that the wood curves inwards towards the hair, so that greater pressure does not cause the hair to be pulled tighter. This makes for a smoother control of tone. The bow is held from the back (i.e. with the hand round the wood), so that the maximum power is available at the heel of the bow directly under the hand. This helps in the accentuation of the music, and encourages firmness of attack and bite.

The reason for the pre-eminence of the strings in the modern orchestra undoubtedly lies in their versatility. The violin itself is in many ways the most versatile of all musical instruments. Admittedly it cannot deal with full harmony like the piano or the organ ; but it has two great advantages. Over a range of at least four octaves it offers complete control of pitch, unrivalled agility, and a variety and flexibility of tone colour second to none. Besides the infinite graduations of expression obtainable by skilful bowing, there are the special effects produced by plucking the strings (*pizzicato*) ; bowing close to the bridge (*sul ponticello*) ; hitting the strings with the back of the bow (*col legno*) ; veiling the tone by fitting a mute over the bridge (*con sordino*) ; and producing a note by touching the string only, instead of pressing it down on the fingerboard (*harmonics*).

The other members of the violin family share much of this versatility, though their satisfactory compass is perhaps slightly less and they do not lend themselves to quite such rapidity of execution.

The Violin

The violins of virtually present-day form first appeared in the middle of the 16th century, in Italy. The only significant changes since then have been a slight lengthening of the neck, thickening of the strings, raising of the bridge, and heightening of the tension. Modern violins are approximately 23½ in. long, with a body length of 14 in., and a length of string from nut to bridge of just under 13 in. The strings are tuned to G D′ A′ E″. Traditionally, the strings are of sheep gut, cut into strips and twisted ; the G string is overlaid with thin copper or silver wire to give it greater weight and sonority. Thin wire or silk is sometimes used for the E string, which has to take the highest tension, and nylon has been tried.



COMPONENT PARTS OF A VIOLIN AND BOW. Further details are given in the text, this page. Instruments of the violin family form the basis of the present-day symphony orchestra.

The viola is really the alto member of the violin family. It is tuned a fifth below the violin to C G D′ and A′, the two lower strings being wire-covered. Theoretically, for this tuning the instrument should be half as big again as the violin; but in practice this would require a phenomenally long arm to play it. So a compromise is reached by making the viola only about three inches longer than the violin, and using heavier strings. As a result the lower notes are apt to be rather hollow in tone, and the higher notes slightly reedy.

The viola, though an alto instrument, plays the tenor role in the string quartet, with a first and second violin above it and a violoncello below. The true tenor violin, tuned an octave below the treble violin and played on the knee, went out of fashion at the end of the 18th century, though parts for it were written by both Bach and Handel.

STRING QUARTET. **Four bowed stringed instruments make up the orchestral string quartet. Normally this comprises two violins, a viola (the alto member of the violin family), and a violoncello (commonly abbreviated to cello), which is the bass of the violin family.**

Cello and Double Bass

In Italian, violoncello means a little "violone" or double bass, so that the contraction cello is, strictly speaking, nonsensical. But it has become so customary, that to speak always of a "violoncello" in full is apt to sound pedantic. The instrument is the bass of the violin family, with two covered and two uncovered strings tuned an octave below the viola to C G D A. For a long time it was played on the knee, but in the middle of the 19th century a peg was added to rest it on the ground. The device is said to have been invented by its first notable virtuoso, A. F. Servais (1807–66), who used it in his old age to make the instrument easier and less exhausting for him to handle. It opened the way for a much more brilliant technique, of which the greatest exponent (until his retirement after the Spanish Civil War) was the Catalan player, Pau Casals (b. 1876).

DOUBLE BASS. **This instrument, strung tight like a violin and bowed like a violin, in tone and attack closely resembles a lower version of the cello. Most double basses now have four strings.**

The double bass is always treated as the lowest member of the violin family, though it is not quite a true violin. It has the flat back and sloping shoulders of a viol. But it is strung tight like a violin and bowed like a violin, so that in tone and attack the double bass closely resembles a lower version of the violoncello.

During most of the 19th century three-string double basses were common, tuned F D G or G D F. To-day most instruments have four strings, usually tuned E A D G.

Woodwind

The woodwind instruments of the orchestra belong to two classes: the flute and the piccolo, in which the sound is produced by blowing through narrowed lips against the sharp edge of a hole; and the oboe, clarinet, and bassoon, in which the sound is produced by reeds. In either case the note is changed by opening a series of holes in the side of the pipe, and thus effectively shortening the air column vibrating inside.

One difficulty of this system, increasing with the size of the instrument, is to stretch the fingers far enough to cover all the holes if these are bored in the scientifically correct positions. Hence the numerous keys and levers that are now regularly used (*see* diagrams in p. 1927). The present system for the flute was devised by the German instrument-maker Theobald Boehm (1793–1881) in the 1830s; and Boehm systems for the other woodwind instruments are in common if not quite universal use.

WOODWIND
These photographs of sections of the B.B.C. symphony orchestra show : 1, the bass clarinets ; 2, the bassoons ; 3, the piccolos ; 4, the oboes.

The modern orchestral flute is the German or transverse flute, which was known in the 17th and 18th centuries but did not become standard until the 19th century. Since Boehm's day it has had a cylindrical bore and a compass of three full octaves, from C′ to C′′′′. The second octave is produced by overblowing so as to sound the second harmonics of the first octave ; the third octave, by further overblowing to sound the fourth harmonics. The piccolo is half the size of the concert flute, and sounds an octave higher. Instruments lower than the concert flute exist but they are not common.

Oboe, Cor Anglais, and Bassoon

The oboe has a double reed, held in the mouth, a conical bore, and a narrow bell. It developed from the medieval shawm and Elizabethan hautboy. Its compass is about two and a half octaves from B or B flat to F′′′ or a note or two higher. Its tone is sharp-edged, rich, expressive, and penetrating. The upper registers are reached by overblowing the fundamental octave

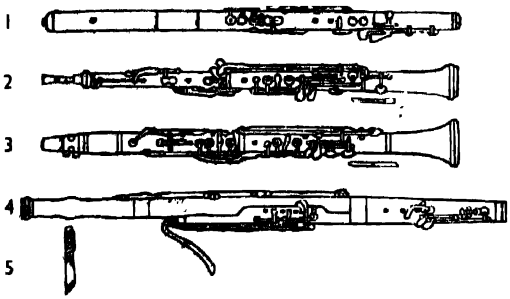
The cor anglais is essentially a tenor oboe a fifth below the standard instrument ; but it has an incurved bell which gives it a softer and juicier tone.

Though it is usually regarded as the bass of the oboe family, the bassoon has a wider reed, a relatively narrower bore, and a much smoother and rounder tone. The tube of the bassoon is doubled back on itself, and the Italians call it *fagotto*, because it looks like a bundle of sticks. In the hands of a good player it can have a compass of well over three octaves, from B flat to E″ flat and even higher. Overblowing produces the octave of the fundamental, and throughout its range the bassoon is remarkably agile.

The bassoon has frequently been called the clown of the orchestra. Haydn wrote occasional comic parts for it, and Mendelssohn made it play Bottom in " A Midsummer Night's Dream." But it is by no means merely grotesque. Its upper registers especially are well adapted to lyrical melody, and in this role it can be not only highly expressive but also extremely moving. In a large orchestra there is also a double bassoon, an octave below the standard instrument.

Clarinet

The clarinet differs from both oboe and bassoon not only by having a single instead of a double reed, but by having a cylindrical instead



1, flute; 2, oboe; 3, clarinet; 4, bassoon; 5, a reed.

of a conical bore. A conical pipe, even though closed at one end by the reed, behaves like an open organ pipe; a cylindrical pipe closed at one end by the reed acts like a stopped organ pipe. This has three important consequences.

In the first place, the fundamental note of the clarinet is an octave below what one would expect from its length. In the second place, only the odd harmonics are produced, so that the tone, particularly in its lowest register (called the chalumeau), is noticeably strange and hollow. In the third place, overblowing cannot produce the second harmonic (the octave), since all the even harmonics are missing: instead it produces the third harmonic, which is a twelfth above the fundamental.

That leaves a gap of a fifth in which the notes can be produced only by means of a further apparatus of holes and keys beyond the requirements of the usual octave instruments. This complicates the fingering to such an extent that it was for long customary for clarinet players to carry two instruments, a B flat and an A clarinet sounding a semitone apart, the former for use in flat keys, the latter in sharp. Both these instruments are transposing instruments; that is, the music for a B flat clarinet is always written a tone above the sound that will be produced; the music for an A clarinet, a minor third above the sounds produced. Thus the fingering is the same in both, and the instrument itself effects the transposition into keys that would otherwise be awkward.

Though the lower register on a clarinet may sound hollow, its upper registers are clear and even brilliant. In military bands, the clarinets usually substitute for the violins in an orchestra, sometimes with the addition of a high and somewhat shrill E flat clarinet. In the symphony orchestra, the clarinets usually rank as the tenor voice in the woodwind quartet. There is also a bass clarinet, which is an octave below the standard instrument.

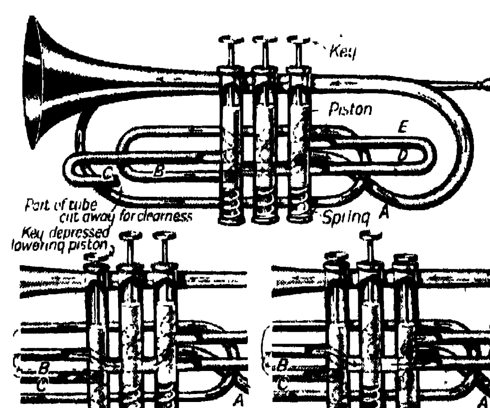
LESSON 9

Brass, Harp, and Percussion

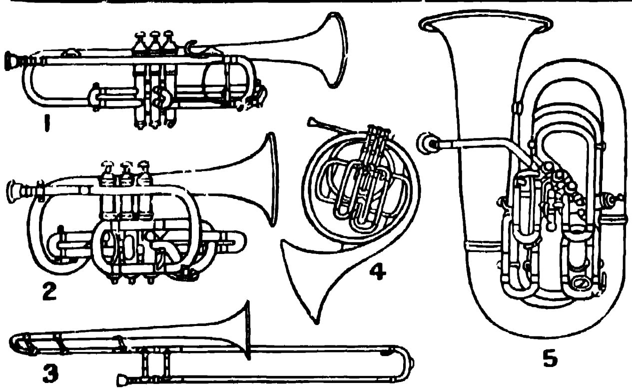
In the brass instruments of the orchestra the sound is made in the first instance by the player's lips vibrating across the opening of the mouthpiece. This sets the air in a long brass tube vibrating; and because the tube is comparatively narrow for its length, the sound produced is strong in upper partials. As a result, the tone is sometimes mellow, sometimes brilliant, but always full and colourful. Also it is comparatively easy for a player, by varying the tension on his lips, to pick out different harmonics to sound instead of the fundamental.

For centuries this was the only way in which different notes were produced by horns and trumpets. Their parts in an orchestral ensemble were thus severely restricted to the notes of a bugle call. The restriction is obvious in the louder passages of any Haydn or Mozart symphony, where the brass will come in to reinforce tonic, dominant, and sub-dominant chords, but may have to give other harmonies a miss. The effect which this produces is noticeable even in some Beethoven symphonies.

The earliest way of overcoming the difficulty was to vary the length of the tube by means of a slide, as in the trombone, which could play a full chromatic scale even in the 18th century. But this system will work only for instruments



CORNET. Top: A, path of air after going through B. Left: extension C (cut away in top picture to show B) is used to give different note; when 1st piston is pressed down, air passes from B and into C, then into A, then out through cone. Right: when 1st and 3rd pistons are depressed, air travels through B, C, D, E, then through A, and out.



WIND INSTRUMENTS IN BRASS. 1, trumpet, also on the left in the top right photograph ; 2, cornet ; 3, trombone, also on the right in the top right photograph ; 4, French horn, also in the top left photograph ; 5, euphonium or tenor tuba, also in lower right photograph. The bass for the orchestral brass is usually provided by the tuba, which is, in effect, a large bugle equipped with valves.

with a cylindrical bore. Those that have a tapering tube, like the horn or the bugle family, cannot accommodate a slide. In the 18th century they were provided with crooks of varying lengths, which could be inserted in the middle of the tube to put the instrument in the right key for any particular movement. Given a few bars rest, the crook could be changed to cope with a modulation in the middle of a movement as well. Once the crook was in, the instrument could again play only bugle calls in the new key, until the crook was changed again.

Problem Overcome

The problem was overcome by the invention of valves in the first half of the 19th century. A valve is an arrangement for bringing in or cutting out a crook at the touch of a single finger. With a suitable equipment of valves it is possible to play completely chromatic passages on any brass instrument, through a range of two, three, or even four octaves.

The 18th-century trumpet was a narrow tube about seven feet long, bent round in a loop, with a shallow cup-shaped mouthpiece at one end a widely-flaring bell at the other. In its lower registers it was subject to the limitations of the bugle call. But in the earlier part of that century it was regularly played in a very high register – from the third to well above the fourth octave above the fundamental note, i.e. from the eighth to the twentieth harmonic and even beyond. Here the harmonics lie close enough together to provide many of the notes of a chromatic scale, and players who specialised in this very high register were called *clarino* trumpeters.

Bach wrote some very high and difficult *clarino* parts—the one in the " Second Brandenburg Concerto " is famous ; but the technique of playing these high harmonics seems to have been lost even before Mozart's day, and in the 19th century there were authorities who suggested that they never were played on real trumpets at all, but filled in by Bach himself with a trumpet stop on the organ.

With the invention of valves early in the 19th century the problem of trumpet-playing was much simplified. The old long trumpet in D gradually went out of fashion, to be replaced

by the modern short trumpet in B flat or A, about 5 ft. 6 in. long. This shorter trumpet is less brilliant than the older instrument (particularly if, for ease of playing, its bore is made conical instead of cylindrical), but it is still the most brilliant of modern instruments, with a tone that can dominate the orchestra.

Horns

The history of the horn is much the same as the history of the trumpet. Bach and Handel and even Haydn wrote very high horn parts that required a special technique to execute. By the end of the 18th century this technique had been lost. Then it was found that by inserting the right hand into the bell of the instrument (hand-stopping), the pitch could be varied sufficiently to produce nearly a chromatic scale. Beethoven's horn parts were written for the hand-stopped natural horn, and are sometimes very difficult indeed—for instance, the famous phrase for fourth horn alone in the slow movement of the Ninth Symphony. The hand horn continued in use until Brahms's day, when it eventually gave place to the valve horn.

This modern horn (often called the French horn) in F is really a tenor instrument, but has a wide compass of over four octaves. Its tube is over 16 ft. long, narrow and tapering, with a wide-flaring bell, and a deep funnel-shaped mouthpiece. The tone is at once mellow and colourful, and is often described as the most "human" voice in the orchestra.

Trombones

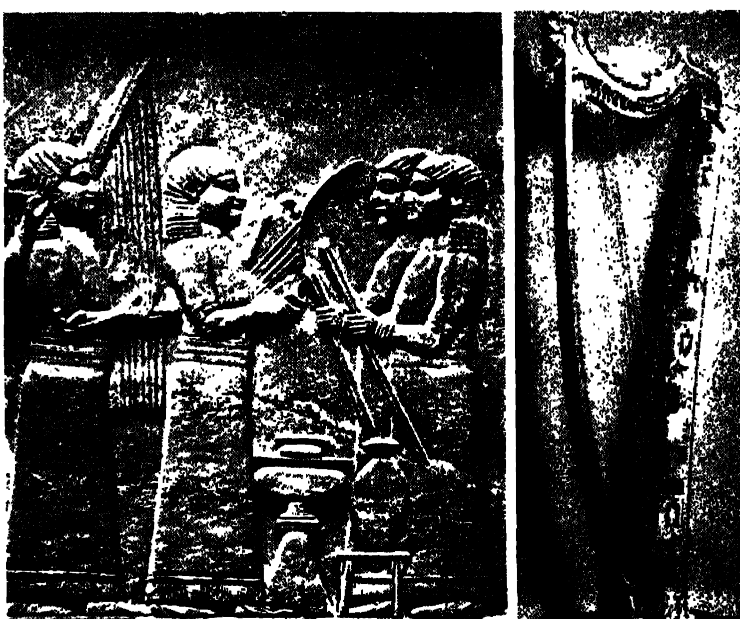
At one time there was a whole family of trombones—soprano, alto, tenor, bass, and contra-bass—all with slides so that they could play a chromatic scale, and all descended from the Elizabethan sackbut. Of these, the only ones which are at all frequently used to-day are the tenor trombone in B flat, which is standard in the modern orchestra, and (less frequently) the bass trombones in G and F. The secret of the rich full trombone tone is the long, narrow cylindrical bore, the moderately flaring bell, and the fairly deep cup-shaped or conical mouthpiece.

The bass for the orchestral brass is usually provided by the tuba, which is, in effect, a large-sized bugle equipped with valves. The bugle family in general have a widish conical bore with a large mouthpiece, and their tone tends to be broad rather than brilliant. Other members are the flügelhorn (usually in B flat); the tenor horn (E flat); the baritone (B flat) and the tenor tuba or euphonium (also in B flat but with a wider bore). These instruments fill the middle parts in the traditional brass band. The orchestral tuba is a bass instrument, either in F or E flat, which in brass bands is called a bombardon. There is also a contra-bass tuba an octave lower in B flat, the coils of which are wrapped round the player, with the bell rising up from behind his head.

The Harp

Harps of one kind and another are among the oldest of musical instruments, and are depicted on Egyptian tombs, Greek vases, and medieval frescoes. The old Irish harp or *clarseach* had 45 wire strings, and a loud ringing tone. The Highland version was gut-stringed, and softer.

The modern chromatic harp was perfected about 1810 by a German instrument maker, Sebastien Erard (1752–1831). It has some 48 strings tuned to a diatonic scale in C flat; and seven pedals, each of which raises one note of



HARPS OF OLD. Musical instruments in the days of Ashurbanipal, king of Assyria 668–626 B.C., are shown on this marble slab (left): a 12-stringed harp, a lyre, drum, and drumsticks. Right, a damascened harp of the 16th–17th centuries, in the Este gallery, Modena, Italy.

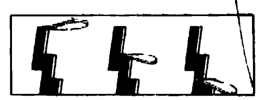
Left, British Museum, photo Mansell; right, Mansell Collection

the scale through all its octaves by one semitone when halfway down (the first action), and a further semitone (making one tone in all) when full down (double action). The strings are of gut, except for a few in the bass, and the tone is liquid rather than brilliant.

Percussion

Percussion instruments are, literally, things that are hit. A remarkable variety of them have been used at one time and another in symphony orchestras. The most orthodox, never absent from a full orchestra, are the kettledrums or timpani. These are large metal bowls with parchment stretched over the top. When hit with felt-headed sticks they make a sound sufficiently regular to have a definite pitch, and are consequently tuned to particular notes as specified by the composer. The usual number is three, sometimes four. Their diameter may vary from 19 in. to 30 in., and their notes from E to G or even higher. Sometimes they may be used to carry a fragment of melody, as in the scherzo of Beethoven's Ninth Symphony, or in the last movement of Shostakovitch's First.

HARPISTS. The contemporary chromatic harp has some 48 strings and 7 pedals. Each pedal raises one note of the scale through all its octaves by one semitone when half-way down, and a further semitone when full down. The pedal action is shown in the diagram on the right.



Other drums used in the orchestra are metal cylinders with two parchment ends: their note has no definite pitch. The side drum has gut strings stretched across the back, which rattle when the other side is hit. This produces the sharp crisp tap and roll of military music. The normal bass drum is about 4 ft. in diameter and delivers a vague deep boom. The so-called Verdi drum is about twice as big, and is deeper and vaguer in tone.

Cymbals

Cymbals are brass plates clanged together with a sliding movement, usually to mark a climax. They can also be suspended and tapped with a drumstick to produce softer effects or a continuous roll.

The triangle is a bent metal rod open at one corner that gives a high silvery tinkle. It is suspended by a string at the upper angle, the string being held in the performer's hand; sometimes the instrument is attached to a drum. It is beaten with a steel rod.

Anvils have frequently been used in operatic music: there are 18 in Wagner's *Rheingold.*

Tubular bells hung from a frame and hit with a hammer do duty for church chimes, as in Tchaikovsky's "1812" Overture.

The glockenspiel is a row of tuned metal bars hit with wooden sticks. Wagner introduced it into the scores of *Der Ring des Nibelungen* and *The Mastersingers of Nuremberg.*

The celeste consists of similar bars, rather deeper in pitch, with wooden resonators underneath and a keyboard mechanism to play them with.

There is also a long, thin, wooden contraption capable of making a sharp cracking sound, and called a whip.

TIMPANIST and percussion section of B.B.C. symphony orchestra. The kettledrums or timpani are never absent from a full orchestra. They are large metal bowls with parchment stretched over the top and they are hit with felt-headed sticks.

LESSON 10

The Orchestra

THE modern orchestra began to take shape at the end of the 18th century. Before that, composers were usually much less concerned about what particular instruments were used to play their works—much less concerned, that is, about timbre and instrumental colour than about the relation of the parts in counterpoint, the succession of harmonies, the shape of the melody, and the musical form.

There were exceptions. Claudio Monteverdi (1567–1643) in Mantua at the beginning of the 17th century wrote operatic accompaniments for a band of 36 instruments, and sometimes used the different sounds which they made for special descriptive effects. Much more typical is the music of the Elizabethan age, which was written for either singing or instrumental playing, and advertised simply as "apt for viols or voices." In Handel's day, strings had become the mainstay of the band which accompanied opera or oratorio, with a few flutes, oboes, bassoons, and trumpets, and a keyboard instrument (organ or harpsichord) to hold things together. Bach seems to have written for whatever instruments were locally available ; and the curious collections of instruments which have solo parts in some of the Brandenburg concertos were almost certainly chosen because expert players on those particular instruments happened to be staying at Köthen at the time.

Orchestral Colour

The idea of an orchestra as a stable, balanced, and disciplined ensemble stems from Johann W. A. Stamitz (1717–57), who assembled and trained the famous Mannheim orchestra in the latter part of the 18th century. This set a pattern which was confirmed in use first by Mozart, then by Beethoven.

Beethoven's orchestra consisted regularly of a smallish group of strings, with two flutes, two oboes, two clarinets, two bassoons, two horns, two trumpets, and two kettledrums. Later he added a third horn, and (in the Ninth Symphony) a fourth. In his opera *Fidelio* he scored for a double bassoon, but he rarely used trombones. It was extraordinary the variety of colour which Beethoven could elicit from these comparatively modest forces. But the man who first really explored the possibilities of orchestral colour was Berlioz.

Berlioz greatly increased the size of the orchestra—his "Requiem" called for well over a hundred players. He made full use of the newly-invented valves, which enabled brass instruments to play an even chromatic scale. He was not musically well educated, and he could play no instruments (except the guitar, very badly). But he had a genius for using each instrument to its best advantage, for blending and contrasting different timbres, for making the changing orchestral colour an integral factor in his music rather than merely an added embellishment.

Development of the Pictorial Element

This has remained the mark of good orchestral music to the present day. It is not a matter of writing the notes first, and then assigning them to suitable instruments. The tone colour is part of the original conception. It changes phrase by phrase, bar by bar, sometimes even in the course of a single chord. It can range from the faintest whisper of muted strings to a crescendo of exultant sound that by its sheer volume takes the breath away. It can be harsh, tender, noble, comic, austere, sentimental, gay, tragic, serene, or infinitely sad.

This discovery of the expressive qualities of orchestra timbres led to a considerable development of the pictorial element in music. Some descriptive or "programme" music had, of course, always existed, and Beethoven's "Pastoral" Symphony is a well-known example. Berlioz carried the idea much further. The five movements of his "Symphonie Fantastique," for instance, are labelled : Dreams, Passions ; A Ball ; Scene in the Fields ; March to the Scaffold ; Witches' Sabbath.

This tradition was continued by Liszt, every one of whose orchestral pieces bears a descriptive title—the "Dante" Symphony, the "Faust" Symphony, "Tasso," "Prometheus," "Mazeppa," etc. Liszt was followed by Richard Strauss with such tone poems as "Don Quixote," in which the sheep can be heard bleating and the windmills turning. By the beginning of the 20th century the tone poem had become a fully recognized and widely cultivated orchestral form.

The Concerto

The concerto was another form which became established in its modern meaning in the 19th century. Earlier concertos, such as those written by Bach and by Handel, were simply orchestral pieces in which passages for the whole band alternated with passages for two or three solo instruments. Since Mozart, concertos have been virtuoso pieces for one solo instrument, in partnership with, or accompanied by, the full orchestra. The commonest solo instruments to be treated in this way are the piano and the violin ; but the effect is different. The piano provides a full

harmony, and its tone stands out against the orchestra, so that in both respects it is on more or less equal terms with its partner.

A solo violin can easily merge into the general texture of orchestral tone, so that both in the writing and in the performance tact is needed to keep it distinct. The same is true in the less common viola or violoncello concertos, in the Brahms double concerto for violin and cello, and in the occasional concerto for a wind instrument—flute, oboe, clarinet, horn, etc.

But always the form of a concerto is essentially symphonic ; and at a certain point in the development, before the return of the first subject, it is traditional for the solo instrument to have a bravura passage to itself, called a cadenza. Originally the cadenza was an extempore performance ; nowadays it is more usual for it to be written down like the rest of the work. In the older concertos (e g. Mozart or Beethoven) different soloists may use different cadenzas ; some may have been written expressly for them, some handed down from the great virtuosi of the 19th century.

The Orchestra To-day

A typical symphony orchestra to-day might be made up of 14 first violins, 12 second violins, 10 violas, 8 violoncellos, 8 double basses, 1 harp, 3 flutes, 1 piccolo, 3 oboes, 1 cor anglais, 3 clarinets, 1 bass clarinet, 3 bassoons, 1 double bassoon, 4 horns, 4 trumpets, 3 trombones, 1 tuba, and 3 percussion players—making 84 players in all. But the numbers are by no means fixed. Many conductors like more strings if they can get them : 16 first and second violins is not unusual, and Sir Henry Wood (1869–1944) used to say that he wished he could always have at least 24. Many scores call for extra instruments among the woodwind, brass, and percussion, and orchestras of well over 100 players are not unusual.

The arrangement of an orchestra on the platform also varies somewhat with different conductors. Usually the first and second violins are on the left, the violas are in the front at the centre, the cellos and basses to the right. The woodwind sit behind the violas, the brass either behind them or to their right next to the double basses. The drums and the rest of the percussion are at the back.

The Conductor

One important respect in which the modern orchestra differs from its 18th-century forerunners is in the position of the conductor. Bach and Handel directed their players from the keyboard. By Beethoven's time, the keyboard "continuo" had no longer a place in the orchestra. Sometimes the leading violinist directed. More frequently a conductor stood in front and beat time. This practice is said to have been introduced from Germany into England by Ludwig Spohr (1784–1859) in 1820. It became more and more common as orchestral music grew more complicated, and by the end of the 19th century conductors like von Bülow, Hallé, and Richter had become as much popular idols as the great instrumentalists and singers.

Interpretation

The conductor's work is not merely to beat time, to cue in the various instruments, and to indicate expression by his gestures. That is merely what the audience sees. His real work is done at rehearsal, and before : first by studying the score himself and working out in his own mind how every detail should be played ; then by working out that interpretation with the players at rehearsal, and then by inspiring them to give of their best when they do appear before an audience.

Much has been said about the differences between one conductor's interpretation of a standard work and another's. There may be obvious differences of tempo and expression, of instrumental balance, and clarity or muddiness of texture. There are much more subtle differences which result from the extent to which the conductor has inspired the orchestra to a genuinely musical utterance. These differences can be studied more easily now - gramophone records of the same work by different conductors can be compared at leisure and in minute detail. In this way it becomes more than ever clear that it is not the violence of a conductor's gestures, or even their expressiveness and elegance, that makes him a great conductor, but a combination of musicianship, personality, and hard work behind the scenes, with complete dedication to the ideal of producing the music for its own sake and as nearly as possible as the composer would have wished it to be heard.

The Score

The best way to learn to appreciate orchestral music is to learn to follow it in a score. This is by no means so formidable a task as it might seem for anybody who has any sort of working acquaintance with staff notation. In an orchestral score the parts played by the strings occupy the five bottom staves, and since the strings are the mainstay of the orchestra it is here one should look first in trying to follow what is happening. The other instruments, when they are playing, are written above—woodwind on top, brass next, then percussion. If there are voices—soloists or choir—they come below the drums and above the strings ; and this is the place also for the solo instrument in a concerto.

The main difficulties in following a score arise first in learning to associate the stave assigned to a certain instrument with the kind of sound which emerges from it. The trumpet, though written often immediately below the bassoon, sounds very much higher and usually more prominent. The most prominent melody will not always be on the top line (devoted usually to a quiet flute); it may even dodge about between two or more lines separated by a considerable distance on the page.

Then there is the problem of transposing instruments. In a work in F major, for instance, the part for the clarinets will be written with a key signature of one sharp, and the sound they will actually make will be a tone below what is written. There may be brass instruments at the same time, with their parts in two flats sounding a fifth below the written notes. This is confusing, and has to be got used to. So does the alto clef in which the violas play.

But even so, by watching the score and listening carefully it is not difficult to learn what is happening. This is particularly true with a gramophone, where a part missed can be repeated till it comes clear. As a result, what before was a mere welter of more or less agreeable sound becomes a brilliantly intelligible pattern of voices and colours, themes and harmonies: becomes, in fact, a piece of music as a musician hears it, with the depth and meaning of a work of art.

LESSON 11

The Older Instruments

Many of the classical instruments of the 17th and 18th centuries went completely out of fashion in Victorian days, and had almost to be re-discovered in the 20th century. Much of the credit for their rediscovery goes to Arnold Dolmetsch (1858–1940), who was born in France of Swiss parentage, and settled in Haslemere, Surrey, in 1914. He learned how to make many of the older instruments, including the harpsichord, taught his family and their friends to play them, started an annual festival in 1925, and succeeded in communicating his enthusiasm to a steadily growing section of musical opinion both in England and on the Continent.

Harpischord

The harpischord was the chief keyboard instrument before the invention of the piano. Its distinctive quality comes from the fact that it plucks the strings instead of hitting them with a hammer. The resulting note is sharper and in a way more brilliant than on a piano, but much less sustained. Typical harpsichord music is therefore more busy than piano music; and the elaborate ornaments of 18th century keyboard music—trills, turns, mordants, acciaccaturas—were developed to maintain the interest in a slow tempo when the individual notes could not be effectively sustained.

Another disadvantage of the harpsichord was that no significant variation in the loudness of the tone could be made by altering the strength with which the keys were hit. In the big harpsichords a certain amount of loud and soft was obtained by having two keyboards operating different mechanisms of plucking (quill, leather, etc.); by having pedals which could vary slightly the extent to which the quill overlapped the string; or even by enclosing the whole instrument in a box with movable shutters like the swell in an organ. In the small domestic

DOLMETSCH FAMILY. Under the leadership of Arnold Dolmetsch (1858-1940) they rescued from oblivion delightful pieces of the 16th-18th centuries, reintroducing the music of the old English school. Dolmetsch was born at Le Mans and settled at Haslemere, Surrey, in 1914. Here he constructed viols, recorders, virginals, clavichords, etc., and with members of his family inaugurated in 1925 an annual musical festival.

harpsichords (called virginals in Elizabethan days, spinets later) none of these artificial aids was available, and expression had to be achieved almost entirely by delicate use of ornament and subtle variations of time.

Partnership with Other Instruments

As against these restrictions, the harpsichord has one or two distinct advantages. When well played, it has great clarity of articulation, so that the inner threads of an elaborate counterpoint are far more distinct, and hence easier to follow, than on the piano. A work like Bach's

HARPSICHORD. 1A, profile of jack: B, plectrum; C, string; D, damper; E, dotted lines show plectrum falling; F, spring. 2 shows working of the jack and the string. CLAVICHORD, 3; AA, pins holding stretched string S; BB, bridges; D, damper; K, key; T, tangent.

"Goldberg Variations," for instance, is incomparably more effective on the harpsichord, for which it was originally written, than on a modern piano, which inevitably blurs its outlines and obscures its brilliance.

It happens also that the timbre of the plucked string blends with other instruments and with the human voice much more completely than the struck string of the piano. The piano, in fact, noticeably refuses to blend with other sounds. In any combination, from a piano concerto with full orchestra to a sonata for piano and violin, the piano stands out against the other instruments, so that the total effect is always of contrast and often of genuine rivalry. The harpsichord merges completely into a partnership with other instruments—particularly strings. Hence its use throughout the 18th century to fill in the harmonies and point the accent in almost any combination of instruments from a simple trio to the largest orchestras then available.

Clavichord

The sound in a clavichord is made by a wedge of metal (called the tangent) which rises to touch the string, but instead of falling away immediately, like a piano hammer, remains in contact; the string then vibrates from the tangent to the bridge. The tone of the clavichord is extraordinarily quiet; but within its own range it can be made louder or softer by varying the strength with which the key is struck. Moreover the pitch can be varied slightly by differences in pressure on the key while the note is sounding. Thus it is not quite so rigidly bound to the temperament in which it is tuned as either the piano or the harpsichord. It shares the clarity of the harpsichord for contrapuntal music, and is known to have been Bach's favourite instrument. Because of the weakness of its voice, however, it has never been practicable to use the clavichord with other instruments, either in partnership or for accompaniment.

The Viols

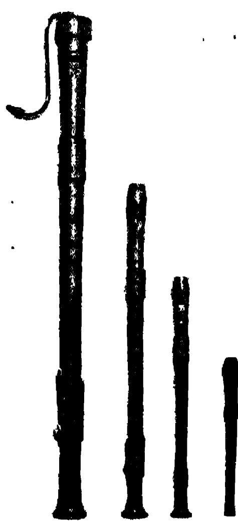
The viols make up a family of stringed instruments, somewhat like the violins in appearance,


HARPSICHORD (left) with 18th-century decorations. CLAVICHORD (right) dated 1751.

and played with a bow, but independent in origin and largely complementary in character. They differ from the violins in having six strings instead of four, flat instead of arched backs, sloping instead of square shoulders, and sound holes in the shape of a *c* rather than an *f*. They are made of thinner wood, and the strings are much less tightly drawn. All sizes are played on the knee, and bowed underarm (i.e. with the hand on the side of the hair). The bows are bend outward, and consequently tighten with increased pressure. The fingerboard is fretted with gut tied round at semitone intervals.

Consort of Five Viols

The result of all these factors is that the tone of a viol is quieter than that of a violin, but edgier, so that counterpoint, especially in the inner parts, is easier to follow when played on viols than on violins. In this respect the viols bear the same relation to the violin family as the harpsichord does to the piano ; and most of the string music written by the great English composers of the 16th and 17th centuries is still heard to better advantage on the instruments for which it was composed.



The full consort of viols consists of five instruments ; a treble viol, tuned D G C′ E′ A′ D″ ; an alto viol one tone below, tuned C F A or B D′ G′ C″; a tenor viol, a fourth below the alto, tuned G C F A D′ G′ ; a bass viol, commonly called viola da gamba, a fourth below the tenor, tuned D G C E A D′, with sometimes a seventh string tuned to a low A ; and a double bass viol or violone an octave below the bass viol, tuned D, G, C E A D..

VIOLA DA GAMBA. This is the leading member of the viol family.

Owing to the slacker tension, the very high notes on the treble viol are not so satisfactory as on the violin, and hence are less used. Moreover the leading member of the family is not the treble viol, but the viola da gamba. Throughout the 17th century and much of the 18th, the normal accompaniment for a solo voice, whether on the stage or in the drawing room, was a combination of viola da gamba to hold down the bass, with harpsichord to fill in the harmonies. This excellent partnership eventually yielded to the growth of the modern orchestra and the development of the piano.

RECORDER QUARTET. Left to right : bass, descant, treble, tenor. In the upper photograph, left to right : bass, tenor, treble, descant. The usual consort consists of these four instruments.

Recorder

The recorder, or English flute, was the flute of the 16th, 17th, and early 18th centuries. It is played downwards instead of horizontally like the transverse or German flute, which is now the recognized orchestral instrument ; but the important difference is that the breath is directed against the edge that produces the tone by a specially-shaped mouthpiece like a penny-whistle, instead of by the lips. There are eight finger-holes, including one for the thumb and one for the little finger. The tone is rather brighter than the transverse flute, and quieter ; the compass is about two octaves.

Consort of Four Recorders

The usual consort consists of four instruments : the descant recorder with a compass from C″ to D″″ ; the treble recorder (acting as alto) a fifth below the descant ; the tenor recorder with a compass from C′ to D‴, and the bass recorder ranging from F to D″. All four instruments tend to sound as if they were

THE LUTE PLAYER. A self-portrait by Jan Steen, famous Dutch painter (1626 79).

playing an octave below their actual pitch ; so that although the compass of each lies a good deal higher than the corresponding singing voice, they do not give an impression of shrillness. The recorder is the easiest of all genuine musical instruments to learn to play, and after its revival in the 1920s it became increasingly popular among amateurs of all ages.

The Lute

Probably because it is so difficult to play, the lute is much less heard now than harpsichords, viols, or recorders. It was the chief instrument of accompaniment in Shakespeare's day, and a much used solo instrument as well. In shape, the lute is like a pear sliced down the middle. Typically, it has upwards of 11 strings, tuned, except for the top one, in unison pairs (called courses). Both strings of a pair are plucked by the same fingers, and chords of three and four notes are played simultaneously. Larger lutes, such as the theorbo, and the arch-lute or *chitarrone*, had extra bass strings off the finger-board, to give a deeper foundation to the chords.

The tone of the lute is soft and (when properly played) very expressive. It blends admirably with the voice as an accompaniment to singing. There is a large repertoire of Elizabethan songs with lute accompaniment, and a large literature also of solo music for the lute which is rarely if ever heard. It is written in a special notation, called tablature.

LESSON 12

Singing

The human voice is the oldest of all musical instruments, and one of the most beautiful ; though at times, and in different countries, widely different views have been held about what does or does not constitute beautiful singing. In India and the Arab world, for instance, highly trained singers hold the muscles of the throat tense, with the voice box retracted. The result is a thinnish nasal tone, uncongenial to European ears ; but by this technique Eastern singers achieve an exactness of intonation in intervals much smaller than a semitone, together with a speed and agility of execution unknown in the West.

Styles of Singing

In Europe, traces of the eastern manner survive in the Spanish type of singing called *flamenco*. It is possible also that the nasal timbre still heard in many Continental church choirs may be the remains of a tradition handed down from medieval times when such singing was the rule throughout Europe.

The style of singing aimed at in Western classical music is entirely different. It calls for a combined roundness and richness of tone, full resonance, and a wide range of dynamics, from the softest of pianissimos to a powerful fortissimo capable of holding its own against a large modern orchestra. To achieve this, the singer must learn to avoid any suspicion of tightness in the throat muscles or retracting of the larynx. The throat should be open, so as to allow of the fullest resonance in the chest, in the mouth, and in the nasal cavities. This does not always (or even often) come naturally : hence the need for training before even the most naturally gifted singer can become an accomplished performer.

Fashions in Western Singing

Within the Western tradition, various fashions in singing have been in vogue at various times. The Italian style called *bel canto* had its culmination in the florid and highly trained vocal gymnastics which were greatly admired in the 18th century. It is doubtful if any singers since have reached such technical perfection ; but even in their own day they were frequently criticised for sacrificing the real content of the music to empty displays of vocal skill. This bad tradition was broken in England when Handel turned from opera to oratorio. The words were now in English, and sung by English

singers ; and their religious basis called for all the sincerity which the artificial Italian opera lacked. On the Continent, Gluck's demand for a greater realism and sincerity in secular opera had much the same effect.

Voice Production

The 19th century saw a steady increase in the demand for sheer volume of sound to dominate larger halls and bigger orchestras. At its best this led to the heroic singing required for Wagnerian opera. At its worst it developed an exaggerated enunciation, a forced tone, and an almost unendurable wobbling of pitch which is politely called a vibrato.

VOICE MECHANISM. **The air passages (marked by arrows) and organs involved in the production of the voice.**

Many systems of training have been practised over the last three centuries, and there is no general agreement as to which is best. Probably there is no one answer. One system may work well for one voice, not for another. Much depends on the experience, judgement, and personality of the teacher.

Whatever the system, the main aims of voice training are the same. They include : (1) the relaxation of the throat muscles, which is the distinctive feature of western singing ; (2) complete breath control from the lungs and diaphragm, so that the outflow of air does not need to be held back by constricting the throat; (3) exactness of intonation, without scooping up to a note or wobbling round it ; (4) flexibility ; (5) enunciation (particularly difficult in a language like English, in which half the vowels are diphthongs, and consonants frequently fall together).

Kinds of Voice

The most famous singing teacher of the 18th century was Niccola Porpora (1686–1767), who visited London and wrote some of the tunes in John Gay's *The Beggar's Opera* (1728). The 19th century was dominated by Manuel Garcia (1805–1906) who taught most of the great singers of the Victorian age, from Jenny Lind (1820–87) onwards. Garcia was the first to apply scientific methods of the study of voice production ; but his theories about "head register" and "chest register" are no longer widely held.

On average, men's voices are pitched about an octave below women's voices. In both, all variations of range are found ; but it is convenient to divide them into three categories : high, middle, and low. Of these, the middle voices (mezzo-soprano and baritone) are in a very large majority. True sopranos or tenors, who can take a high A or B with comfort, are rare ; true basses or contraltos, descending easily to a low D or E, are hardly more frequent.

Among sopranos it is customary to distinguish the coloratura soprano, with a high register of flute-like tones and great agility ; the dramatic soprano, with a more powerful voice and greater emotional expressiveness ; and the lighter lyric soprano. Similarly, tenors tend to divide into the Italian type of operatic tenor (*tenore robusto*) ; the even more powerful heroic tenor (*heldentenor*) associated with Wagnerian roles ; and the altogether lighter, but still expressive, lyric tenor.

High-pitched boys' voices are called trebles. The word recalls the early days of church music, when basses were never used, the main tune was in the tenor, and the treble was the third voice counting from the bottom. Boys' trebles have a purer and less emotional quality than sopranos a quality which many people feel is particularly suited to church music. The (male) alto or counter-tenor, heard chiefly in English cathedral choirs, is a carefully developed falsetto voice with a range comparable with contralto.

Crooning

The invention of the microphone led to a popular style of singing as far removed from the classical Western ideal as the latter is from the trained Eastern fashion. The microphone relieves the singer of the necessity to produce any considerable volume of sound. Instead, a soft, confidential murmur, often breathy, and without ring or resonance, is amplified to any loudness required. Crooning is passionately condemned by classical musicians ; but it is not quite clear whether it is the actual timbre of the resulting sound which they dislike, or the poor quality of the songs crooners sing, and the tricks of over-sentimentalising and singing off the note which they affect.

LESSON 13

Dance Music and Jazz

THE difference between dance music and classical or "serious" music is nothing new. It has always existed in the European tradition. It is true that the medieval monks would sometimes take a popular dance tune and weave it into a setting of the Mass, just as to-day a dance-band leader will sometimes take a tune from Handel or Beethoven and turn it into a fox-trot. But the mere fact that this gave rise, then as now, to horrified protests is evidence of the gulf which has always separated "serious" from "popular" music.

This gulf was not really bridged by the custom in the 17th or 18th centuries for composers to cast some of their best works in the form of suites of dance movements. It is doubtful if anybody ever danced to the bourrées and gavottes, gigues and sarabandes, of Bach's Suites, much less to the minuets which regularly formed the second movement in the symphonies and quartets of Haydn and Mozart. In any case, these represented elegant court dances, not the folk dances of the people, which were usually accompanied by a single fiddler, a one-man-band of pipe and tabor, or a set of bagpipes.

In the 19th century the situation was much the same. Quadrilles and lancers, polkas and galops, hardly affected serious music; and the classical waltzes, such as those of Chopin and Brahms, were not much used to dance to. Toward the end of the century a half-way house of light music developed, which was at its best in some of the operettas of the period, and in the waltzes of Johann Strauss.

Ragtime

The kind of music now called jazz began to take shape during the 1890s among Negro players in the southern states of America and notably in New Orleans. At first it was called ragtime, and was obviously descended from the cakewalks and jigs of the old minstrel shows, of which the best known is probably "Turkey in the Straw." Ragtime had certain tricks of rhythm, which seem to have been part of the African inheritance of the American Negroes: they mostly come under the heading of syncopation, which implies the omission or displacement of the regular accent in a simple measure to give the effect of a cross rhythm.

The other important characteristic of ragtime was that it was largely improvisation. Many of the early ragtime players were unable to read a note of music. They played by ear, keeping to the simplest of harmonies, and making up decorations and variations for the tune as they went along. They also ignored the classical tradition in the way they played their instruments, using the piano with a strong percussion effect, and making wind instruments imitate the inflexions of the human voice.

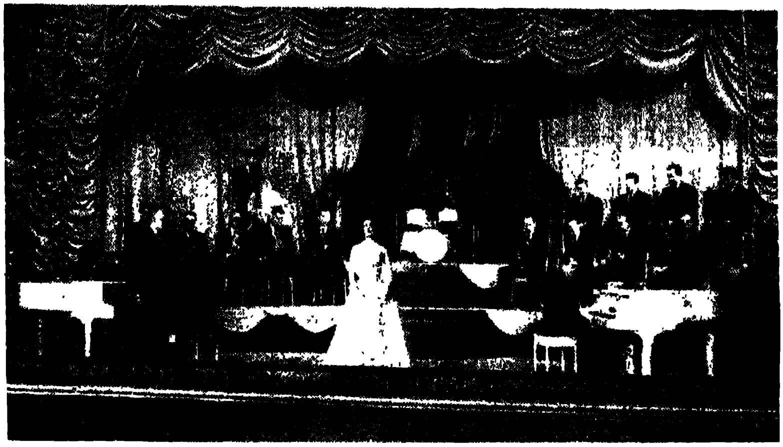
Early in the 20th century a slightly different style developed. The blues were originally a vocal form, and owed much to the tradition of Negro spirituals. The words were simple love complaints, written in a mood of melancholy tinged with humour. In the accompaniments, and in the instrumental forms which came later, slightly more sophisticated harmonies began to appear, with a tendency towards chords of the seventh ("barber-shop harmonies"), combined with a modification of the major scale in which the third and seventh degrees (mediant and leading note) were frequently flattened. They were called the "blue notes," and in genuine blues the flattening stopped short of a full semitone, so that the note actually sung or played lay between the keys of the piano. Characteristic of the blues also was the "break"—a short improvised cadenza (usually about two bars long and highly syncopated) at the end of certain lines of the song.

TRUMPETER LOUIS ARMSTRONG, one of the greatest names in the early development of jazz.

One of the greatest early exponents of the blues was the Negro singer Bessie Smith. The famous "St. Louis Blues" was produced by W. C. Henty (a cornet player) in 1914; his "Memphis Blues" of 1909 is one of the first published examples.

"Hot" and "Sweet"

By the early 1920s, ragtime and blues had merged into a style which seems to have been first called jazz in 1916. Several bands had migrated from New Orleans to Chicago, and



FAMOUS RHYTHM BAND. When Ted Heath's celebrated band, specialising in rhythm emphasised by brass and percussion, toured the United States in 1956 it surprised and delighted American audiences with its original treatment of and approach to jazz. Ted Heath is seen standing on the left, in front.

there began to make gramophone records. Since jazz is essentially an extempore art, the gramophone record was the only form in which it could be preserved, and the sales of jazz records soon exceeded the sales of the corresponding sheet music. The development of radio also enabled a single band to reach a much wider immediate public.

Probably the greatest name in this early development of jazz is that of the trumpeter Louis Armstrong (b. 1900) whose "Hot Five" (sometimes "Hot Seven") were at the height of their fame in the mid-20s. Armstrong stuck to the New Orleans style of improvisation. At the same time there grew up among other bands the habit of arranging pieces, and then keeping to the orchestration and decorations thus settled, during the recording session or public performance. Paul Whiteman (b. 1893), also a trumpeter, is said to have been the first who insisted that his band should keep strictly to the notes set down. Whiteman spoke of symphonic jazz, and commissioned George Gershwin (1898–1937) to write the "Rhapsody in Blue."

The method of fixed arrangements was already widespread by the end of the 1920s, and the two styles were roughly distinguished as "hot" and "sweet." Hot jazz went in for more or less continuous extemporisation, and a good deal of calculated off-the-note playing, and rough instrumental tone. Sweet jazz used arranged orchestrations and much less "dirty" playing. But the distinction was far from clear-cut; and a band such as that of "Duke" (Edward K.) Ellington (b. 1899), which was one of the most famous of the 1920s, made use of both techniques; fixed arrangements were worked out in rehearsal, but allowed specified points for selected instruments to "take it to town" in extempore solos.

Swing

In the 1930s extempore playing returned to fashion, largely under the influence of the American clarinettist Benny Goodman (b. 1909). The new craze acquired a new name: swing. The distinctive thing about swing seems to be an accompaniment in strict time, against which a solo instrument allows itself very wide variations of tempo (an extreme example of *tempo rubato*). A common feature of the accompaniments was the insistent repetition of a single short rhythmic figure, called a "riff," instead of a mere succession of vamped chords.

Out of swing grew eventually the jam session, in which not only one but several instruments (theoretically, all the instruments of the band) are free to improvise simultaneously, held together only by the succession of simple harmonies provided by the initial tune.

Another development from swing was the style of piano playing called boogie-woogie, characterised by the continuous repetition of a short rhythmic figure like a riff in the bass, set against free improvisation for the right hand.

Jazz Bands

It is customary to divide the typical jazz band into two parts: the rhythm section and the wind section. The usual members of the rhythm section are piano, guitar (often fortified by electric amplification), string bass (a double bass plucked rather than bowed), and a complicated collection of drums, cymbals, gongs, wood blocks, xylophones, marimbas, and cuban rattles, called collectively "traps." The wind section includes trumpets and trombones (often played with mutes), clarinets, and saxophones.

The saxophone is a keyed metal instrument with a wide conical bore, and a single reed like a clarinet. It was invented by a Belgian, Adolphe Sax (1814–94), in mid-19th century, and was much used on the Continent in military bands. Its tone is comparatively weak in upper partials; and this gives it a somewhat bleating sound, which has not yet recommended itself to many orchestral composers. Its agility and flexibility, and the wide range available with instruments of various sizes, are valuable assets

in jazz. Other instruments are occasionally used, and the habit of one player "doubling" two or more instruments is common.

Most jazz bands feature also a singer. The early Negro singers had powerful voices, but the use of a microphone rapidly made this unnecessary. For a time, a style of singing cadenzas of nonsense syllables (so-called scat-singing) was in vogue. Its best known exponent was "Cab" (Cabell) Calloway (b. 1907). Later, this gave place to crooning, as popularised by "Rudy" (Hubert Prior) Vallee (b. 1901) and "Bing" (Harry Lillis) Crosby (b. 1904).

There is a good deal of modern dance music which is not, strictly speaking, jazz. Waltzes are an obvious example ; also the Spanish or South American forms: tango, rumba, mamba, conga, etc. Moreover, many white bands lack the element of improvisation, which is an essential part of true jazz, even at its sweetest. But jazz rhythms and the jazz style in playing and singing have affected practically all music for ballroom dancing to-day.

There have even been attempts to import the jazz idiom into classical music. The first of these was probably "The Golliwog's Cakewalk," written by Debussy in 1908. There was Stravinsky's "Soldier's Tale," and "Ragtime for Eleven Instruments," both in 1919, Ernst Křenek's opera, *Jonny Spielt Auf* (Johnny Strikes Up) in 1927, and Constant Lambert's "Rio Grande" in 1929. But on the whole the jazz idiom is too restricted for extensive use in classical forms and, in any case, it rapidly loses its distinctive flavour when the element of improvisation is removed.

LESSON 14

Early Composers

LITTLE is known about the lives and works of the pioneers of consonant harmony, records being few and scanty. The invention of the stave has usually been attributed to the Italian Benedictine monk, Guido D'Arezzo (born about 1000), because he was a great populariser of music in his day.

He travelled through France, settled at the Abbey of St. Maur-des-Fosses, and there taught the notes of the scale by the use of the syllables, *ut, re, mi, fa, sol, la*, taken from the first syllables of the lines of a popular hymn in Latin, each one of which began on a higher note than the last. He may not have invented the stave, but he enabled people to use it.

Discovery of Harmony

Something more exciting was pulsating in the musical life of Europe in the 11th century—nothing less than the discovery of harmony. About this time the idea arose that music might add a third dimension to its resources ; instead of having only rise and fall in pitch, and differing durations of time—which may be compared to height and breadth—depth was now added in the relations of simultaneous sounds.

The 12th century saw the development of polyphonic musical composition by Leonin and Perotin, two composers at the school of music in the newly built Cathedral of Notre Dame in Paris. Alongside sacred music the secular melodies of the troubadours began to flourish, and continued through the 13th into the 14th century. The pastoral play *Robin et Marion*, by Adam de la Hale (1285), is a landmark at this period.

In the 14th century Philippe de Vitry (*c.* 1285-1361) in France formulated his *Ars Nova*, and Guillaume de Machaut (*c.* 1300-77) was the principal musician who in ballads and chansons disseminated its principles. A parallel movement started in Italy under Francesco Landini (*c.* 1325-97), a pioneer of the madrigal. Guillaume Dufay (*c.* 1400-1474), in the Netherlands, who had been a singer in the Pontifical Chapel at Rome, composed simple Masses.

Following him were, in England, John Dunstable (died 1453) and Robert Fayrfax (1450-1520), organist of St Albans Abbey. Josquin Des Pres (1450-1521) composed much sacred music, and was organist of Cambrai Cathedral. Jacob B. Arcadelt (*c.* 1514-1575), a chorister in Tours and later in Venice, wrote secular and sacred part-music. Sweelinck (1562-1621) was organist of Amsterdam Cathedral after being a chorister at Louvain.

Music's Debt to Palestrina

Music had before this time become a definite art and was no longer ancillary to poetry. As an embellishment to church services it developed still further, but religious music and secular music reacted on each other, and were affected by technical advances in either province, and thus the harmonic forms of modern music began to evolve.

Giovanni Palestrina (1524-94), Italian composer of the 16th century, entrusted by the Council of Trent with the task of remodelling the music of the Church, is considered to be the first musician who reconciled musical art with musical science. He wrote many inspired Masses, masterpieces of unaccompanied singing, each voice part moving in an independent and melodious flow of sound, the whole effect being all that could be desired in religious music.

THREE EARLY COMPOSERS. Giovanni Pierluigi da Palestrina, left (1524–94), born at Palestrina (whence his name), was master of music at the Vatican and St. John Lateran. Thomas Tallis, centre (c. 1515 85), was organist of Waltham Abbey until its dissolution in 1540 and later of the Chapel Royal. William Byrd, right (c. 1542 1623), was a pupil of Tallis, and in 1575 the two published a collection of motets. Byrd was one of the greatest musicians of his age.

No sacred music had been heard like it before, and none better has been heard since. The most famous of all is "Missa Papae Marcelli," and every music-lover should seek an opportunity of hearing this and Palestrina's other works performed, as they far exceed in beauty of actual sound their appearance on paper. In addition, he composed two volumes of madrigals. His polyphonic works form an epoch in the history of music.

Orlando Lassus, or di Lasso (*c.* 1530–94), born at Mons, stands out as the chief name in the Flemish contrapuntal school. As a chorister in the church of Mons he had such a beautiful voice that he was three times kidnapped and taken to Sicily to sing in the choir of the viceroy. He was afterwards director of the choir of St. John Lateran, Rome, a post of great importance; he travelled in Germany, and died at Munich. He composed over 2,000 sacred and secular works and was a man of great charm and courtly manners. Under Palestrina and di Lasso the art of counterpoint reached perfection.

Church and Secular Music

Two other great masters in the "polyphonic" period are of England and Spain respectively—William Byrd (*see* later paragraph) and T. L. de Victoria (*c.* 1535–1611). Victoria's music is more rich than the high serenity of Palestrina: it is church music charged with a strong mysticism. In secular music, the madrigal or elaborate part-song was coming to perfection in Italy with Luca Marenzio (1553–1599), whose compositions had a considerable influence on English music of this period. Marenzio was strongly chromatic in style, but not so experimental as Carlo Gesualdo, prince of Venosa (1560–1613), whose works are prophetic in their sense of harmonic effect.

At the end of the 16th century a new school of harmony began to arise, and the elaborate choral writing gave way to the single voice, or monody. Much of this revolution was precipitated by Claudio Monteverde (1567–1643), who laid the foundations of the modern orchestra, and indeed of modern vocal music.

Fine Poetry and Fine Music

In the Tudor era English musicians travelled much abroad and their music was well-known in Europe. Secular music at this time was an informal and aristocratic art in the main. Concerts were unknown, but music was a part of every gentleman's education. In addition, the common people had their own folk music of popular songs, as can be seen from Shakespeare's constant allusions. Choral and solo song flourished side by side, and there was that perfect conjunction of fine poetry and fine music to which John Milton (1608–74) refers in his phrase, "sphere-born, harmonious sisters, voice and verse."

Christopher Tye (*c.* 1497–1572), chorister at King's College, Cambridge, and musical instructor to Edward VI, received his Mus. Doc. from Cambridge in 1545, from Oxford in 1548. Organist at the Chapel Royal under Queen Elizabeth I, he composed fine services and anthems, among which occur phrases now well-known in their adaptation for hymns (Dundee and Winchester Old). John Merbecke, or Marbeck (*c.* 1512–85), organist of St. George's Chapel, Windsor, is remembered by church-goers for his setting of the First Book of Common Prayer to music.

Tallis and Byrd

Thomas Tallis (*c.* 1515 85) rose to fame by his Festal harmonic setting of the Responses; his tune in canon to the "Evening Hymn" is equally popular. He has been called "the father of English cathedral music," and described as "one of the greatest contrapuntists of the English school." He was the author of a motet in forty parts, that is, eight choirs of five voices each. With William Byrd (*c.* 1542–1623), Tallis was granted by Queen Elizabeth the exclusive rights to print and sell music-paper for twenty-one years. William Byrd, the greatest English musician of the Tudor period and founder of the English madrigal school, also composed fine church music, and instrumental music. His "Non nobis Domine" is often sung as grace. He was called the "Palestrina of English music."

Composers who brought the arts of the madrigal and lute songs to a high pitch of beauty were: Thomas Morley (1557–1603), pupil of

Byrd, organist of St. Paul's Cathedral, and composer of much excellent secular music, including that for Shakespeare's song "It was a lover and his lass"; John Dowland (1563–1626), lute-player and composer to Charles I and at the Danish court; Thomas Weelkes (*c.* 1575–1623), organist at Winchester College and later of Chichester Cathedral, whose secular madrigals have imagination and colourful harmony, Orlando Gibbons, John Willbye, Thomas Campion, Francis Pilkington, etc.

Dr. John Bull (*c.* 1562–1628), who wrote much for the virginals and other keyboard instruments of the time, was organist to James I in 1607. One of his tunes somewhat resembles the National Anthem, and may have been one source of its origin; historically he may be said to be the founder of the modern pianoforte repertory. He was the first music lecturer (1596) of the famous Gresham College in London, where the Gresham lectures are still given yearly. From the extreme difficulty of his instrumental music, his reputation as a player seems to have been well deserved.

LESSON 15

The Seventeenth Century

The 17th century was marked throughout the music schools of Europe by the development of opera, of oratorio, and of the various forms of aria; by greater freedom in the use of established forms, and in particular by experiments which followed on the departure from the old rule of counterpoint that a dissonance must either be "prepared" (appear as a consonance in the previous chord) or be led up to gradually.

HENRY PURCELL (c. 1658–1695). Born in London, he became organist of Westminster Abbey in 1680, and of the Chapel Royal in 1682.

The new departure was due to Claudio Monteverde (1567–1643), who by using "unprepared" discords asserted their individual rights and duties and freed them from the bondage of being mere variations of concords. Monteverde was a most distinguished composer of operas, especially developing the orchestra: in his grand opera *Orfeo* the band included viols, violins, harps, trumpets, trombones, and several small organs.

Outstanding Figures

Giacomo Carissimi (1605–74), organist in Rome, if not the actual originator of the oratorio form, greatly developed the sacred cantata. One of the finest of his oratorios is *Jephtha*. Robert Cambert (1628–77), a distinguished harpsichord player and operatic composer, joined the band of Charles II in England. An outstanding figure was the Florentine Giovanni Baptista Lulli (1639–87), usually known as Jean Baptiste Lully, who founded the school of grand opera in France. Starting life in the train of the Chevalier de Guise, Lully was taken when a boy to Paris. His violin playing and social gifts so pleased Louis XIV that he was made director of the royal orchestra, and subsequently granted a monopoly for operas in Paris (1672).

Lully's productions were magnificently staged and dressed; by introducing the ballet as an essential part of the opera he greatly enhanced its spectacular success; he also invented the overture. His chief compositions were light operas, the most popular being *Armide*, *Phaëton*, and *Acis et Galatée*. A chief characteristic of the important French school started by Lully was its attention to drama. He set some of Molière's comedies to music, and occasionally appeared in his own productions.

The great improvement in violin making in Italy during the 17th century led to an advance in solo playing. Arcangelo Corelli (1653–1713), the first really great violinist, composed many concertos. Alessandro Scarlatti (1659–1725) greatly developed the aria, both in opera and in the cantata, and is still remembered by such charming songs as "Violets, dainty violets." His aria innovation was the "second part" followed by a repetition of the first strain (da capo).

Composers and Organists

The French composer François Couperin (1668–1733), organist of St. Gervais in Paris, is chiefly renowned for his beautiful harpsichord music, which influenced Bach. Some of his compositions have descriptive and fanciful names, such as "Cuckoo," and "Les petits moulins à vent." Jean Philippe Rameau (1683–1764), who was organist in Paris and at Clermont in Auvergne, where he wrote his world-famous theoretical analysis of acoustics and harmony, developed the work of Monteverde. He composed operas after the style of Lully, his best being *Castor et Pollux*, produced in Paris in 1737. He wrote twenty-one operas and ballets and many pieces for the harpsichord.

Some of his gavottes, and the beautiful organ " Pastorale," are still heard on occasion.

In England during the middle of the 17th century the Puritan rule had had a considerable modifying effect upon church music. Elaborate services were suppressed, but secular music was allowed to continue. The great age was spent in its force, and few composers were left to maintain the English tradition. Among the few were Thomas Ravenscroft (*c.* 1590–1633), who set to music the metrical Psalms, and wrote many hymn-tunes, a number of which are still well known ; his reputation is also kept in memory by the popular round " Three blind mice "—this was originally in the minor key, not the major.

Also of this period were Dr. William Child (1606–97), a noted organist, and Henry Lawes (1595–1662), who wrote choral works, including Charles II's coronation anthem. He was the friend of poets, and, a singer himself, it was he who commissioned the young Milton to write the masque of *Comus*. These composers had been "children" of the Chapel Royal in Charles I's time.

" Master of the Children "

With the restoration of the monarchy, music came more into its own again and the re-opened Chapel Royal again became a training school. Many of its pupils achieved success as composers in later years. The first " Master of the Children " after the Restoration was Captain Cooke (*c.* 1616–72), a former " child," who proved an excellent choir trainer ; most of the English leading musicians of the immediately subsequent period were under his guidance.

Matthew Locke (*c.* 1630–77) is chiefly known by his music to *Macbeth*. Michael Wise (*c.* 1648–87) was a composer of anthems and organist of Salisbury Cathedral ; as " king's organist " he had the privilege of playing for the king at whatever church the monarch went to. Dr. John Blow (1648–1708) was noted for his anthems, and was organist of Westminster Abbey. Pelham Humfrey (1647–74) went to study opera under Lully, and on his return was made " Master of the Children." Dr. William Croft (1678–1727), whose anthems and funeral service are still used, was organist of St. Anne's, Soho. Henry Carey (*c.* 1690–1743) was distinguished for lighter compositions, notably " Sally in our Alley," and ballad operas.

Henry Purcell

The greatest English composer of his time, and one of the greatest in English history, was Henry Purcell (*c.* 1658–95). Entering the Chapel Royal as a " child " at the age of six, Purcell proved an apt pupil of Captain Cooke and later of Humfrey and of Dr. Blow ; when he was eleven he composed an " Ode of Welcome " to the king, " on his Return from Newmarket." In 1679 he succeeded to the position of organist at Westminster Abbey, and in 1683 was made organist of the Chapel Royal. Having studied the Italian composers, Purcell went from strength to strength in his compositions of all kinds : services and anthems for the Abbey, many of which are still performed, dramatic and chamber compositions. He wrote many pieces for the organ and harpsichord, composed twelve sonatas for two violins and a bass, and his dramatic works include the music for Shakespeare's *Tempest* and for Howard and Dryden's *Indian Queen*, the songs for Dryden's *King Arthur*, and the miniature opera *Dido and Aeneas*. This latter work was composed for a boarding-school for young gentlewomen at Chelsea, and was performed by them, the composer himself taking part. A well-known tune associated with, and possibly composed (or adapted from a folk tune) by Purcell is " Lillibullero." The early death of this composer was a great national calamity. His choral style undoubtedly influenced that of Handel. He was buried in his beloved Abbey at Westminster, near which he was born. This is the inscription :

Here lies Henry Purcell Esq. who left this life, and is gone to that Blessed place where only his harmony can be exceeded.

LESSON 16

The Eighteenth Century

In the 18th century European music devoted its attention to the perfecting of form and manner, to the achievement of a perfect style in instrumental music. The predominant influence was German and Austrian. Bach and Handel, to begin with, were followed by Hadyn, Mozart, and Beethoven. The desire for clear musical thought and simplicity of harmony led them to heights and depths of feeling that have seldom been reached since.

Music was regarded at this period as an abstract art. Opera developed only incidentally, and then upon formalised lines. Haydn constructed out of the experiments of J. S. Bach's son, Carl Philipp Emanuel Bach, the new form of the symphony and sonata. Mozart, following his lead, made even greater strides in the organization of formal musical sounds. Beethoven stands in the middle, between the classical composers and the romantic expressionists.

The influence of Italy upon these German masters should not be forgotten.

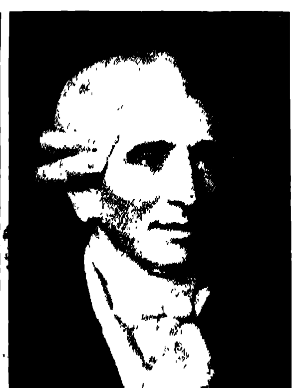
GEORGE FREDERICK HANDEL (1685-1759). His first opera was produced at Hamburg in 1705. From 1710 until his death he lived chiefly in England, composing and organizing the performance of many operas, beginning with "Rinaldo." After 1737 he produced a number of oratorios, until in 1752 he became totally blind.

Scarlatti and Handel

The year 1685 saw the birth of Domenico Scarlatti, George Frederick Handel, and John Sebastian Bach. Domenico Scarlatti (1685-1757) was the son of Alessandro Scarlatti, and hence an Italian by birth; but he spent most of his life at the Spanish court. His harpsichord sonatas are among the most delightful keyboard works of the 18th century. Handel and Bach were born within a month of each other, the former at Halle, the latter at Eisenach. In boyhood Handel was discouraged from adopting a musical career; Bach had the advantage of coming from a family who had long been established as professional musicians. Handel was for most of his life a public figure, writing and producing Italian operas for the London stage, then turning (for financial reasons) to oratorio in English and developing it into a national institution Bach had no such public career: he remained an obscure organist, or kappelmeister, in small German towns; he held to and perfected the old polyphonic style which was already going out of fashion, and it was not until many years after his death that his work came gradually to be known and his greatness recognized.

George Frederick Handel (1685–1759) made a great success of his operas in England. After study, travel, and work, both playing and composing, in Italy and elsewhere, he returned to Hanover in 1710, and was made court musician to the Elector (afterwards George I of England); but leave was granted him to visit England and in the same year he made London his home. Here his first opera, *Rinaldo*, was produced at the Queen's Theatre, Haymarket, in 1711, with enormous success, and in 1713 he composed the first "Birthday Ode" to English words. In 1714, with the arrival of George I, Handel settled definitely in London, and in 1720 the Royal Academy, "to secure a constant supply of operas by Handel," was founded in the Haymarket, to be closed in 1728. He himself occupied the position of harpsichordist, equivalent to conductor in later times.

But his losses on operatic productions were so tremendous, owing to difficulties with singers and rivals, that his operatic days were ended in 1737, after a severe illness, and he began his immortal work of oratorio composition. The *Messiah*, written in 23 days, was first performed in Dublin in 1742. *Samson*, *Joseph*, *Judas Maccabaeus*, *Susanna*, *Israel in Egypt*, and others followed, his last oratorio being *Jephthah*. Handel festivals were held at the Crystal Palace over a great many years from 1859.



BACH AND HAYDN. John Sebastian Bach, left (1685-1750), was born at Eisenach, Thuringia. He wrote a vast quantity of cantatas and other music. Franz Joseph Haydn, right (1732-1809), the son of a wheelwright, was born near Vienna. He wrote his great oratorio "The Creation" in 1798.

Bach

Handel and Bach never met, although Bach made several attempts to see his famous contemporary. From a choirboy in Lüneberg, by way of a court appointment at Weimar, Bach, member of a distinguished Thuringian musical family, became organist at Arnstadt. Here he wrote much of his sacred music, and later returned to Weimar, where he studied the Italian composers. It was at Leipzig, where he was cantor of the Thomas Kirche, after 1723, that his settings for the story of the Passion, his Mass in B minor, and his grandest cantatas were

Bach was regarded in his own day as an expert player on the organ, and a learned musician. His compositions, written as they were for immediate, occasional performance in the small towns where he variously lived, were unknown, even in Germany, in his lifetime. But his music left behind it a tradition, and its revival after his death grew in importance, and to-day Bach is revered and loved as no other composer, except possibly Beethoven.


MOZART AND BEETHOVEN. Wolfgang Amadeus Mozart, left (1756–91), was a musical infant prodigy, and before he was ten he had been taken by his father on several concert tours in Egypt. Ludwig van Beethoven, right (1770–1827), spent most of his life in Vienna. His finest works were composed after he had become deaf.

Haydn

The father of the symphony and string quartet, Franz Josef Haydn (1732–1809) was born at Rohrau, near Vienna. A choir boy at the cathedral, he later held the position of director of music to Prince Esterhazy. His works—which are very numerous—include 104 symphonies, numerous string quartets, sonatas, and divertimentos, and the oratorios *The Creation* and *The Seasons*. His style of orchestration had an influence on the works both of Beethoven and of Mozart. Haydn was remarkable for the geniality of his temperament and for the absolutely practical outlook he adopted towards music. Underneath the manners of a court musician Haydn showed deep human understanding without ever appearing to be inquiring into the final causes of human happiness or sorrow.

Mozart

Wolfgang Amadeus Mozart (1756–91), born at Salzburg, was an infant prodigy, travelling with his father as a professional pianist from the age of 6. The promise of his early genius was amply fulfilled. He established himself among the greatest operatic composers of the world, with *The Marriage of Figaro*, *Don Giovanni*, *Cosi fan Tutte*, and *The Magic Flute*. As a symphonist Mozart was supreme ; equally, as a writer of concertos for solo instruments he had no rival ; in fact, he established the accepted form of the concerto for all to follow. His works include other compositions—in all, he wrote the prodigious number of 624. He was gifted with an inexhaustible strain of pure melody, and the classical spirit of the 18th century found in his works its perfect expression. In spite of his extraordinary industry, he was always poor, and he died of consumption at the age of 35.

BEETHOVEN'S LIFE MASK. Taken in 1812, it reveals the rugged simplicity of his face at a period of great mental struggle during the comparatively unproductive years 1810–17. In 1818 he composed the tragic Hammerclavier Sonata

Beethoven

Ludwig van Beethoven (1770–1827), born in Bonn, is often regarded as the link between classicism and romanticism in music. A man of great intellectual power, who inherited the classical manner from his predecessors, he was also moved temperamentally by the stirrings of the human soul towards expression so characteristic of his time, represented by Goethe in Germany and Wordsworth in England. Beethoven's architecture in music remains grandly classical, but in his symphonies and later sonatas and quartets he plumbed spiritual depths untouched by composers before or since. Of all symphonists he is accepted as the master : he wrote nine in all, the last of them having a choral movement to end it. He also composed one opera, *Fidelio*, several overtures, one oratorio, numerous smaller works, and much chamber music. In addition to lessons from Haydn in

counterpoint, he took a few lessons in Vienna under Mozart, whose influence is seen in the younger composer's early works. Later on, Beethoven's genius completely asserted itself, and the third and last phase of his style is more seriously and deeply beautiful than ever before. His music is great and permanent because it was the utterance of a great and powerful mind, finding a true and sincere expression by creating, with heavy effort and search, its own proper musical language.

THOMAS ARNE (1710–78) was born at Covent Garden, London: his first composition appeared in 1733. He composed two oratorios, "Abel" (1755) and "Judith" (1761).

Besides these five magnificent composers there were other musical writers of note in the 18th century. The operas of Christoph Willibald von Gluck (1714–87) are more serene and less full of sparkling melody than Mozart's, but as a reformer of the operatic stage in Paris, Gluck paved the way for the great composers who followed him. *Alceste*, *Iphigénie en Aulide*, and *Orphée* are his best-known operas.

Carl Maria von Weber (1786–1826) improved on Gluck's ideal in his "music dramas" *Der Freischütz* and *Oberon*. He was essentially a composer for the stage, in the exciting and romantic traditions of his period. His influence was considerable, and his achievement would have been greater if he had not died so young.

In Italy, Luigi Boccherini (1743–1805), of Lucca, was a noted cellist and composed some excellent chamber music. Domenico Cimarosa (1749–1801) was educated in Naples, but for four years held a court appointment in St. Petersburg under Catherine II of Russia. His great success, the comic opera *Il Matrimonio Segreto*, is remarkable for its lively charm.

GLUCK. His "Alceste," "Iphigénie en Aulide," and "Orphée" did much to revolutionise Italian and French opera. A German (1714–87), he lived for many years in Paris, and around his work and that of his rival Piccinni developed one of the most famous feuds in musical history.

After the painting by J. S. Duplessis

The exalted position held by Handel in England was the beginning of the foreign domination which obtained in matters musical for over a century in Britain. After the German composer's death Thomas Arne (1710–78) tried to carry on the Handelian standard, but failed in the grand style, though he left charming melodies, such as the settings for "Where the bee sucks," and other Shakespearean songs; he composed several oratorios, and the national air "Rule Britannia." William Boyce (1710–79), beginning as a chorister at St. Paul's, became organist at the Chapel Royal, and ranks high amongst English composers of church music; particularly beautiful and impressive is his anthem "Oh, where shall wisdom be found?"

Another composer who carried on the important tradition of cathedral music was William Crotch (1775–1847), and Samuel Wesley (1766–1837) did much to promote a love of Bach in England. The chief composers of the popular glees and catches of the time were Samuel Webbe (1740–1816), R. J. S. Stevens (1758–1837), and Dr. J. W. Callcott (1761–1821). Two notable song writers were Charles Dibdin (1745–1814), whose "Tom Bowling" and "Poor Jack" are best remembered out of his hundred sea songs, and William Shield (1748–1829), who wrote "The Wolf," a descriptive bass song, and was appointed composer to Covent Garden in 1778.

LESSON 17

The Romantic Period

Franz Schubert (1797–1828), born 27 years after Beethoven, died one year after Beethoven's death. To an even greater extent than Beethoven, Schubert was affected by the new nature-loving, expression-seeking tendency of the age. But in his handling of his musical material he remained a classic to the end. Despite his few years of life and the adverse conditions under which he had to compose, Schubert was very prolific with his works.

He was easily touched by sights and sounds outside music, which led him to be very

responsive to lyric poetry. His natural control over musical forms made him one of the greatest of all song-writers: in over 600 songs he never repeated himself or sank into mere formula. The "Unfinished Symphony," so universally popular, marks not the closing of a career but the opening of new and original vistas in music, to be closed only by an untimely death.

SCHUBERT, BERLIOZ, AND LISZT. **Schubert (1797-1828)—according to Liszt "the most poetical musician who ever lived"—suffered neglect during his short life. He brought to perfection the art of song construction. Hector Berlioz, centre (1803-69), French composer of romantic overtures and symphonies, won the Grand Prix de Rome, 1830. Franz Liszt, right (1811-86), Hungarian pianist and composer of "atmospheric" rhapsodies, settled in Weimar as conductor to the opera in 1849 and later directed the Academy of Music in Budapest.**

Berlioz and Liszt

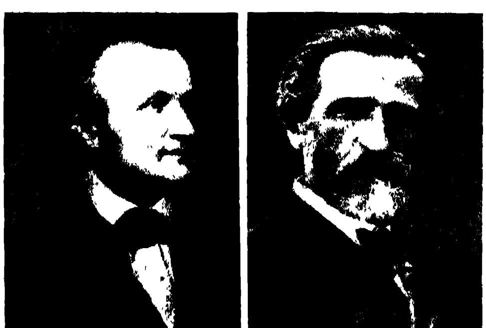
After Beethoven, symphonic and operatic music in the 19th century both show a romantic trend, expressionism ruling over form. Instead of classical perfection, composers now aimed at communicating emotions and dramatic effects. In the realm of opera, this meant development with a wide-spreading influence, because never before had the drama and the music been so closely allied. Programme music—in which the composer "tells a story," thus bringing in a literary, romantic interest, instead of being content with music as an "abstract" art—was definitely created by Hector Berlioz (1803-69), a French composer of remarkable if erratic genius, whose best-known works are the opera *Le Troyens*, an oratorio *The Damnation of Faust*, and the "Fantastique" and "Romeo and Juliet" Symphonies. Berlioz's contribution to the development of the orchestra is without parallel in history.

The Hungarian Franz Liszt (1811-86) was a virtuoso pianist, whose compositions, including the famous "Rhapsodies Hongroises," are of great originality and embody descriptive passages and atmospheric effects. Liszt, with his keen sense of the texture of sound, further developed the romantic programme piece.

Wagner

But musical romanticism was carried to the peak by Richard Wagner (1813-83) in his music-dramas. Wagner's music has a power of penetration and a sure capacity for attracting popular attention unrivalled among all composers. He devoted himself entirely to opera, and his aim was to reform its structure—to combine acting, staging, music, and poetry in one work of dramatic fitness, instead of focusing on the musical composition.

Influenced by the earlier theories of Gluck and by Berlioz, Wagner's inspiration was Beethoven, and this master's development of instrumental music formed a basis on which Wagner freely experimented, liberating it from the conventions and traditional forms previously forced on operatic compositions. To attain complete success in the new structure, which Wagner called "The Art Work of the Future," required that the composer himself must equally combine all the arts. Wagner, the great musical genius, wrote libretti which, in comparison with the magnificence and subtleties of his music, were ordinary; and though much of his stage direction was an immense improvement on the old methods of production, it remained forced and stilted. In his later operas, e.g. *Tristan and Isolde*, the musical side is emphasised and the dramatic appeal lessens.



SUPREME CREATORS OF MUSIC-DRAMA. **Wilhelm Richard Wagner, left (1813-83), was born in Leipzig. He passed twelve years in exile, owing to political upheavals in Germany, and after his return he was relieved of financial stress by a pension from Ludwig of Bavaria and settled in Bayreuth. Giuseppe Verdi, right (1813-1901), born near Busseto, won supremacy as leader of the old school of Italian opera, and afterwards of the new.**

After years of hard struggle and work along standard lines, his first opera to be produced was *Rienzi* (1842), refused in Paris, but accepted in Dresden. Next year there followed *The Flying Dutchman*. The idea of the latter opera, with its wonderful tone pictures of storm, came to him on a tempestuous voyage in a sailing ship. *Tannhäuser* (1845), at first a failure, was followed by *Lohengrin*, *The Mastersingers of Nuremberg*, and *Tristan and*

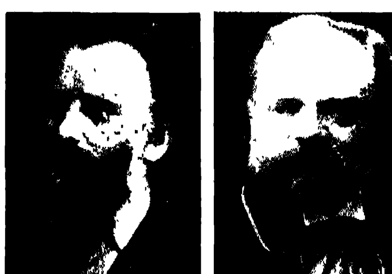
MASTERS OF ROMANTIC MOVEMENT. Mendelssohn, left (1809–47), achieved immense popularity during his lifetime: his incidental music is among the best ever written. Schumann, centre (1810–56), ranks with Schubert in the beauty of his songs. Chopin, right (1810–49), occupies a unique position in the world of music as a pianoforte composer.

Isolde. Wagner's struggles to impose his revolutionary operatic theories continued, and his health was almost on the point of succumbing to the strain, when Ludwig II, king of Bavaria, invited him to complete his work in Bayreuth and with a pension.

The theatre at Bayreuth, where periodical Wagnerian festivals have been held, was built on lines suggested by him, and opened in 1876 with *The Ring of the Nibelung*, a cycle of four operas—*Rhinegold*, *The Valkyrie*, *Siegfried*, and *The Twilight of the Gods*. In 1882 the first performance of *Parsifal* was given there. The influence of Wagner on both opera and symphonic music has been so immense that only of late years have composers begun to free themselves from romanticism, and a reaction towards the classical in composition has set in.

Verdi

Wagner's greatest contemporary in opera, born in the same year, was the Italian composer Giuseppe Verdi (1813–1901). His earlier works owed something to Bellini, and continued the Italian tradition. *Ernani*, produced in Venice in 1844, achieved a success, and numerous operas followed, among which *Rigoletto*, *Il Trovatore*, and *La Traviata* scored triumphs; but they are conventional in type. All belong to the Italian opera school, from the conventions of which Verdi, after much study and long abstention from output, broke away in *Aïda* (1871), and in *Othello*—both of which operas show Wagnerian influence, a complete change in Verdi's method. In the last of his operas, *Falstaff*, composed at the age of 80, both orchestration and stage sense are as brilliant as in *Othello*.



BRAHMS AND DVOŘÁK. Johannes Brahms, left (1833–97), most intellectual of German 19th-century composers, was born at Hamburg. In 1872 he settled in Vienna. Here he introduced to the musical public the work of the Bohemian composer Antonín Dvořák, right (1841–1904).

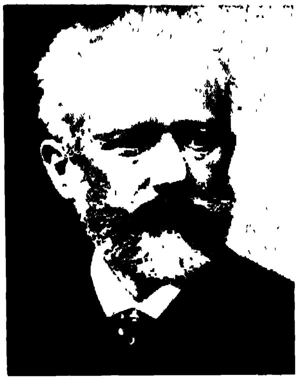
Two earlier operatic composers of note were the German Jew Jakob Meyerbeer (1791–1864) and the Italian G. Antonio Rossini (1792–1868). While still a child Meyerbeer began his career as a brilliant pianist. He attained fame as a composer after study in Italy, with the production of his operas *Robert the Devil* and *The Huguenots*. Though severely criticised by Wagner for his sacrifice of art to artificiality, Meyerbeer won great popularity throughout Europe, even eclipsing his contemporary, Rossini, whose best-known works, among his twenty operas, are *The Barber of Seville* and *William Tell*, and, among his religious compositions, his *Stabat Mater*, first sung as a whole in 1842. Operas of lighter texture were composed by Auber (*Masaniello*) Bellini (*Norma*), Donizetti (*The Daughter of the Regiment*), Offenbach (*Tales of Hoffmann*), and Humperdinck (*Hänsel and Gretel*).

Smetana

The romantic movement led to a strong nationalist feeling in some countries, the most important of them being Bohemia and Russia. In Bohemia the most striking figure was Bedrich (Frederick) Smetana (1824–84). After a varied musical career Smetana returned to his native Prague as director of the national opera, and produced there his popular comic grand opera *The Bartered Bride* (1866). His cycle of symphonic poems "My Fatherland," and his quartet "From My Life," are landmarks in 19th-century music.

Apart from opera, the romantic spirit found expression in the compositions of the Germans Felix Mendelssohn-Bartholdy (1809–47), Robert Alexander Schumann (1810–56), and Johannes Brahms (1833–97); the Pole Frédéric François Chopin (1810–49); and the Bohemian Antonin Dvořák (1841–1904). Mendelssohn (Bartholdy was his mother's name) produced an immense quantity of music in a very few years; all kinds except opera—from the oratorio *Elijah* and the incidental music for *A Midsummer Night's Dream* to the simple piano pieces which he called "Songs Without Words."

Chopin and Schumann, definitely romantic yet perfect in their way, are seldom solemn and ponderous, but are often full of deep feelings. Chopin created a new style of piano composition —many of his lovely harmonics are built up on the rhythm of Polish national melodies. Schumann's fertile imagination and originality enabled him to bring a freshness to his work, the unconventionality of which delayed the recognition of his genius.

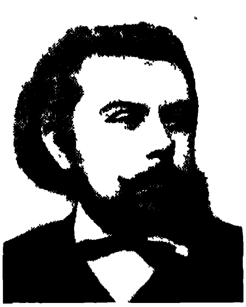


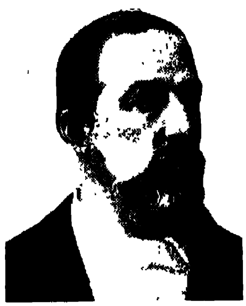
TCHAIKOVSKY (1840 93), whose symphonies and ballet music enjoy world-wide popularity, was more "Europeanised" than his contemporaries: he was less influenced by his own Russian folk-idioms.

Brahms and Dvořák

Johannes Brahms (1833-97) was a typical product of 19th-century German romanticism. But he was by temperament a Nordic, not a Southerner, and he avoided thus all emotional excess and all the temptations of his age towards expressionism and literary pictorialism. His musical instinct was, indeed, that of the pure classic, who seeks the expression of his ideas rather through perfection of style and restraint of phrase.

Brahms is never cold, but in technique he has the detachment of a great master. He excelled in the larger forms of chamber music, wrote four symphonies which have won a place second only





to those of Beethoven, and in song-writing showed a natural lyricism that places him on a level with Schubert. His "Requiem" is much sung. Brahms was extremely interested in folk song, particularly that of Hungary and the East, and his style was influenced more by folk song from outside Germany than by any previous composer.

Following the splendid lead of Smetana, Antonin Dvořák (1841-1904) worked his way from the position of a Bohemian peasant to that of a world-famous composer. His great start in life was given him by Brahms, who happened to read some of his compositions before he had met him. Dvořák was a prolific composer, a singer of numerous melodies, which were tinged with his native Czechoslovak colouring. His *Stabat Mater* for chorus and orchestra made friends for him in England; later, he went to America as head of a musical college, and there composed his "New World" Symphony, in which some influence of Negro songs may be found. Dvořák has a great following, keeping his place by the spontaneous simplicity of his melody.

"The Five"

In Russia, *A Life for the Tsar* by Michael Glinka (1803-57), and his *Russlan and Ludmilla*, established a new tradition of national opera. A strong group of composers soon followed Glinka's lead: he had a firm style allied to a sense of the picturesque, and was therefore a powerful leader, especially with his passion for his country's own folk song. A group known as "The Five" grew together -- Balakirev, César Cui, Borodin, Mussorgsky, and Rimsky-Korsakov. Balakirev (1836 1910), with his tone-poems "Russia" and "Tamara," and his piano rhapsody "Islamey," was the leader and master of the group.

Borodin (1834 87) is known for his opera *Prince Igor*, his second symphony, and his string quartet. Mussorgsky (1839-81), most powerfully original of them all, lives on in his opera *Boris Godunov*. A revised version by Rimsky-Korsakov was first known outside

GREAT RUSSIAN COMPOSERS. Rimsky-Korsakov (1844-1908), whose portrait is reproduced above from the painting by V. A. Seroff, retired from the navy to devote himself to music. Borodin, left (1834-87), and Mussorgsky (1839-81), belonged with Rimsky-Korsakov to the Russian nationalist school of composers.

Russia, but Mussorgsky's stark and powerful original score later became available. Rimsky-Korsakov (1844–1908) was perhaps the most accomplished of this band, but not so strong in originality. His operas, *Ivan the Terrible*, *Snow Maiden*, *Sadko*, and *Coq d'or*, and his symphonic suite "Schéhérazade," continue popular with a public accustomed to the brilliance of the modern orchestra.

GRIEG AND RICHARD STRAUSS. **The music of Grieg, left (1843–1907), has a poetic lyrical quality, reflecting the colour of his native Norwegian fiords. Richard Strauss, right (1864–1949), developed ingenious orchestral effects.**

Tchaikovsky

Standing quite apart from this nationalist movement was another Russian composer of outstanding talents, Peter Ilyitch Tchaikovsky (1840–93). Russian in temperament, Tchaikovsky went to European models, from Mozart to the Italians, for the basis of his style, and hardly used Russian folk-idioms at all. A lonely, brooding, and melancholy man, he found release for his black moods in composing music which ranges from utter despair to brilliant hilarity and hysterical joy. Tchaikovsky's music wears its heart upon its sleeve.

Only parts of his operas are well-known (e.g. the Letter Song from *Eugene Onegin*), but his ballets *Swan Lake*, *Casse Noisette*, and *Sleeping Beauty*, his piano concerto and violin concerto, his Fifth and "Pathetic" (Sixth) symphonies—with their brilliant orchestration, their moodiness, and their sense of effect—are common property in Britain and America. He studied in the conservatorium at St. Petersburg, established by Anton Rubinstein (1829–94), one of the finest pianists ever known.

Grieg

Another composer of markedly national idiom was Edvard Grieg (1843–1907). After some study in the conventional school of Leipzig, Grieg found his native Norwegian music through the teachings of that passionate nationalist, Ole Bull, who toured the world playing Norwegian melodies on his violin. Grieg had considerable success as a pianist, and as accompanist to his wife when she sang his songs. His music has melodic charm, a quaintness of idiom, and the sadness of the fiords and mountains. It has always been popular in England, especially his "Lyric Pieces" for pianoforte, and his two "Peer Gynt" suites.

Bizet, Saint-Saëns, Franck, Strauss

In France, Georges Bizet (1838–75) scored a huge success with his opera *Carmen*, which he did not live to see, for he died a month or two after the first performance, at which it was unrecognized and a failure. Delicate, charming, full of character and wit, Bizet's music to *L'Arlésienne* and his "Children's Games" are popular, and *Carmen* still holds the boards. François Charles Gounod (1818–93) had once an enormous public, not only with his opera *Faust* but with his church music. With all his gifts of melody and drama, the effeminacy of his music has not stood up to the test of time.

Camille Saint-Saëns (1835–1921) was one of the most generally gifted musicians of his time. His fluency was astonishing. But he had not an intellect comparable with his talents, and he is known to-day through one or two symphonic poems, his opera *Samson and Delilah* and his piano concerto in G minor.

A Belgian by birth, César Franck (1822–90) lived most of his life in Paris, pursuing the somewhat lonely path of a church organist and teacher. He may be called the leader of French

FRANCK AND SAINT-SAËNS. **A Belgian by birth, César Franck, left (1822–90), lived most of his life in Paris. Camille Saint-Saëns, right (1835–1921), is known to-day specially for his opera "Samson and Delilah."**

romanticism; serious, personal, and sincere, but rather heavy and mystical. His D minor symphony, "Symphonic Variations" for piano and orchestra, and violin sonata have won for themselves a firm place in the orchestral and chamber music repertory.

Richard Strauss (1864-1949) followed in the train of Wagner, and produced some astonishing orchestral innovations in his tone-poems, "Till Eulenspiegel," "Don Juan," and "Death and Transfiguration," but his music rather closes a period than opens a door to a new one.

LESSON 18

Modern Music

THE history of music in the 19th century is marked by the growth of the romantic spirit, and the dominance of the German tradition from Beethoven to Wagner. The reaction began in France in the 1890s, and led to a period of iconoclasm and experimentation that reached its height in the decade immediately after the First World War. This was followed by a phase of consolidation and more assured achievement.

Emancipation of the Composer

The most notable characteristic of the whole period has been the emancipation of the composer from the old-established rules of classical form and classical harmony. Modern music may be in any key, or no key, or several keys at once. No discord is considered too harsh for use; no progression too irrational. With this has gone a parallel emancipation from the square-cut rhythms of the 18th and 19th centuries—in instances a return to the freer rhythms of plainsong and the Elizabethan madrigal, in others a lively experimentation with compound metres and even more complex rhythmic patterns. The reaction from the romantic ideal has also brought an austere avoidance of emotionalism and a return to contrapuntal forms characteristic of neo-classicism.

Debussy

The first outstanding composer in modern times to assert his right of freedom of speech and to maintain that right by the inherent greatness of his mind was a Frenchman, Claude Achille Debussy (1862-1918). He has special interest because he was so intensely individual and personal, and at the same time he found a response to his questionings in many countries outside France. He had an absolutely certain ear for the right expression of his moods. He worked on no theory, yet he set down, in sound, exactly what he intended to express. His career was always that of a composer, but he was much influenced by the painters in France of his day—that powerful yet delicate Impressionist school who succeeded in putting into colour in a new way what they saw of the sun and the shadows through the atmosphere around them.

Debussy's music is very luminous: the light shines through it. But the sun is not always blazing, and he is aware of the shadows. "L'Après-Midi d'un Faune" depicts the dreamy mood of a siesta. Debussy writes about clouds and the vague movements of the sea and a submerged cathedral, equally with more precise things like a carnival fête and the children's toy-box, with "The Golliwog's Cake-Walk." Debussy was a seeker after peace and quiet beauty, stillness and shadows, but he was never negative. In his piano pieces he evolved a new keyboard technique, and he adapted to his own use the whole-tone scale (the scale that reads C, D, E, F♯, G♯, A♯ [B♭], C), used by Dargomijsky in Russia a quarter of a century before him.

MAURICE RAVEL (1875–1937), a lively and active pupil of Fauré, was influenced by Debussy.

The French School

Another French composer, Maurice Ravel (1875–1937), lively and active, did not stand and ponder as Debussy did. In his music there is great delicacy, but it is the delicacy of precision. The French school in music has a strong history behind these two leading masters. Fauré, a writer of beautiful songs and chamber music, Dukas, known by his amusing piece "The Sorcerer's Apprentice," Florent Schmitt, Chausson, Albert Roussel, were followed by "Les Six" and others of a newer age. Of these, Arthur Honegger and Darius Milhaud (both born 1892) made the greatest mark. In all modern French music can be found much quick humour and bright colour and lightness of touch.

Debussy was undoubtedly influenced by the Russian school of the mid-century, and by Grieg, the Norwegian whose influence

was perhaps greater than his own musical achievement. Out of Russia was to come also a new school of composers.

The Russian Influence

In 1910, at the Russian Ballet of Diaghilev, there appeared a startling new work by a brilliant young composer named Igor Stravinsky (born 1882). He was then 28, and the ballet was called *The Firebird*. It was followed by *Petrouchka*, *The Rite of Spring*, and *Les Noces* (The Wedding). Stravinsky as a composer has always had a magnificent technical skill. He uses that skill with great insight into the future and a complete disregard for tradition. In *The Rite of Spring* he shocked the world with a barbaric splendour of clashing discord and savage rhythm. After the First World War he turned his back on the opulence of his early ballets and cultivated a more and more austere neo-classicism. Of this the chief landmarks have been "Oedipus Rex" (1926-7) to a Latin text by Jean Cocteau, the "Symphony of Psalms" (1930), "Persephone" (1934), "Symphony in C" (1940), and "Symphony in Three Movements" (1945).

In some ways Stravinsky's place in 20th-century music resembles Picasso's in painting. He has never been content to settle down in one successful style, but through every successive phase of experiment has always been in complete control of his medium. And he has always had a power of compelling people to listen: hence both his popularity and his influence on other composers.

Scriabin (1872–1915) still has followers for his piano works, but his more ambitious tone-poems have not kept their once considerable public. Out of the Soviet régime a number of interesting composers have arisen. Shostakovich (born 1906) attracts particular attention. Prokofiev (1891-1953) charmed first with ballet (*Chout*) and opera (*The Love for Three Oranges*), and then with his Mozart-like "Classical Symphony," and his concertos.

STRAVINSKY AND PROKOFIEV. Igor Stravinsky, left (born 1882), had his ballet, "The Firebird," produced when he was 28. This was followed by "Petrouchka" and other brilliant works. Prokofiev, right (1891–1953), gained wide popularity in the 1940s with his ballet "Peter and the Wolf."

Schönberg's Influence

The tendency of the centre of Europe has been very different from that of the nationalists. They have, it seems, approached music rather from the inside than from the outside—from the problems of theory rather than the problems of effect. Arnold Schönberg (1874-1951) was a man of most powerful mind and strong individuality. He began as something of a late romantic, in the manner of Wagner and Richard Strauss; reaching a breaking point, he sought an outlet in the development of his own new chromatic theory of harmony. He discarded the traditional scales and key relationships, and worked out a system designed to treat all the 12 notes of the chromatic scale on an equal footing. In the note-row system these 12 notes are arranged in a particular order at the beginning of each work, and the whole of the music is thereafter derived from those notes in that order.

Schönberg's influence has been very wide, his own achievement considerable, but whether his is the main stream of music or a backwater cannot yet be decided. His two most successful disciples were Alban Berg (1885–1936), whose opera *Wozzeck* and violin concerto attracted attention all over the world, and Anton von Webern (1884–1945).

SHOSTAKOVICH AND SCHÖNBERG. Born in 1906, Shostakovich, left, attracted great attention by his symphonies and incidental music. Arnold Schönberg, right (1874-1951), developed his own new chromatic theory of harmony. His influence has been very wide and his achievements considerable.

BARTÓK AND KODÁLY. A composer of the front rank, Bela Bartók, left (1881–1945), was an ardent student of Hungarian folk songs, which he used as material for his compositions. His compatriot Zoltán Kodály, right (born 1882), shared with Bartók in the study of folk music.

In Germany the chief figure after Strauss has been Paul Hindemith (b. 1895), who reacted so completely against the romantic tradition that he declared music to be merely a matter of craftsmanship. His best-known works are the opera *Mathis the Painter*, and the "Philharmonic Concerto," which gives a bravura part to each department of the orchestra in turn. A Munich composer, Carl Orff (b. 1895) attempted a return to popular appeal by avoiding all complications of harmony and elaborate melody, and building his works out of rhythmic repetitions of short simple phrases and figures.

Hungarian Composers

Hungary's contribution has been mainly through three composers. Ernst von Dohnányi (born 1877) is one of the most accomplished musicians of his time ; a famous pianist, he has written many charming pieces which hold the public. Bela Bartók (1881 1945) was a composer of the front rank. An ardent student of his native folk song, he used it as material for his composition with something of the combined intellectual and emotional powers of a Beethoven. His compatriot Zoltán Kodály (born 1882) is equally sincere but of a more delicate and serene nature.

Finland has produced a composer who stands higher in public favour as a great master than perhaps anyone else of his generation—Jean Sibelius. Born in 1865, Sibelius studied both at home and abroad, and since he was 32 has received a subsidy from the government to allow him to devote his whole time to composing. His works mount up to a very large number, of every class and kind. Some, of a lighter kind (like the theatrical "Valse Triste," and the patriotic march-piece "Finlandia"), have attained world-wide popularity. Of late years it is as a symphonist that he has reached his widest musical public. He has written seven symphonies of great power, originality, and diversity. He shows an innate musical capacity for building a large structure by means of developing small phrases. Sibelius is a composer on a big scale : his command of the orchestra is unbounded, it seems, and yet he can use the simplest of material. Other well-known works of his are the "Swan of Tuonela," "En Saga," and "Tapiola," all tone-poems based upon the rich folk lore of Finland.

Late in the 19th century a new operatic composer arose in Italy who carried on some of Verdi's success, Giacomo Puccini (1858–1924). He won enormous popularity with his operas *Madame Butterfly*, *Tosca*, *La Bohème*, and *Gianni Schicchi*. A power of condensing his phrases was added to a subtle sense of colour and characterisation, and enough of originality to interest without startling ; these and his melodic flow were the gifts that brought Puccini to the fore. Other well-known Italian opera composers are Pietro Mascagni (1863 1945) (*Cavalleria Rusticana*), Ruggiero Leoncavallo (1858 1919) (*Pagliacci*), and Ermanno Wolf-Ferrari (born 1876) (*The Jewels of the Madonna*). Italian composers outside the operatic tradition include Ottorino Respighi (1879–1936), G. Francesco Malipiero (born 1882), and Luigi Dallapiccola (born 1904), a disciple of Schönberg.

SIBELIUS (b. 1865) reveals rugged strength and grandeur in his magnificent symphonies. His tone-poems are based on the folk lore of Finland.

A new nationalist school in Spain came in with Isaac Albeñiz (1860–1909) ; after a career as a pianist he devoted himself to composition on the basis of his national melodies. The delightful balance of picturesqueness and classical form won a permanent place for his "Iberia" suite and other piano pieces. He was a successful opera composer in his own country. Enrique Granados (born 1867, drowned by enemy action at sea 1916) was more modernistic in feeling ; so, too, is Joaquin Turina (born 1882). Undoubtedly the flower of the new Spanish school was Manuel de Falla (1876–1946). He showed in his music the hardness and brilliance of the Spanish temperament, the waywardness of their folk songs.

MASTERS OF THE SPANISH IDIOM. Albeñiz, left (1860–1909), lived long in London, and Paris as composer and pianist. His work is nationalist in character, and he had a pronounced feeling for tradition. Manuel De Falla, right (1876–1946), also developed a national manner.

The story of the modern English revival is perhaps the most fascinating in Europe. In barely half a century England climbed from a low level of achievement to the front rank, and is now able to place her composers on an equal plane with those of any country in the world.

After the death of Purcell the stream of English music flowed but fitfully, kept in its course to a great extent by the traditions of the cathedrals. A new tributary seemed to appear in Sterndale Bennett (1816–75), but the flow was insufficient. Arthur Sullivan (1842–1900) had great talents, but he endures to-day mostly as a composer of light opera—the Savoy operas with librettos by W. S. Gilbert (1836–1911). To the theatre he brought skill and care and musicianship of an unparalleled standard.

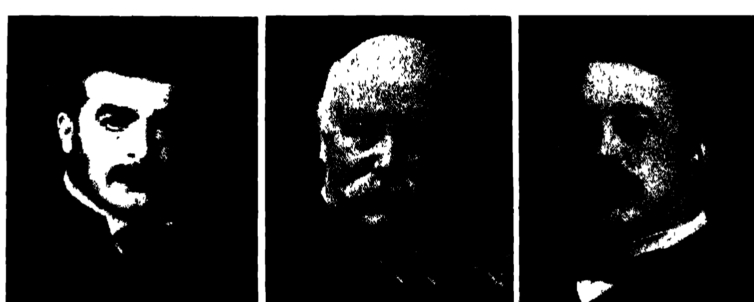
It was with Hubert Parry (1848–1918) and Charles V. Stanford (1852–1924) that English music began the ascent to a place worthy of its old traditions. Parry was a man of manifold abilities and unbounded energy. His life-work perhaps lay more in his untiring labours as director of the Royal College of Music in London than as a composer. But he produced one melody which to-day rivals the National Anthem in popularity—"Jerusalem"; his songs and part-songs (especially "Songs of Farewell") are much sung, and they had the effect of bringing English poetry and English music together again, more closely than they had been joined since Milton's day. His oratorios are still sometimes sung. The prolific Stanford also lives more to-day in his influence as a teacher, which was profound and far-reaching, and is indeed the foundation of the modern English school. With the English Parry and the Irish Stanford was associated a Scotsman, Alexander Mackenzie (1847–1935), principal of the Royal Academy of Music and a composer of distinction.

Edward Elgar (1857–1934), a violinist and organist, came to composing through unofficial and unacademic channels. The English choral festivals gave him his real opportunity, and we owe to them his oratorios and cantatas, of which the most famous are the setting of Cardinal Newman's poem *The Dream of Gerontius*, *The Apostles* and *The Kingdom* to Biblical words, and *The Spirit of England*. The "Enigma" Variations preceded by some years his two symphonies, violin and violoncello concertos, and a group of chamber-music works. Elgar was a composer of colour; his designs are strong and plain, but his decoration of these noble lines is always vivid and imaginative. A Roman Catholic, he had a strong strain of aspiration, and another of patriotism.

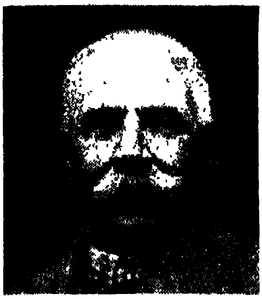
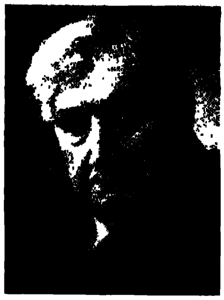
Dame Ethel Smyth (1858–1944) achieved a compromise between academic and experimental forms. Her operas *The Boatswain's Mate* and *The Wreckers* won for her a unique place in musical history. Her finest work was possibly her Mass in D.

Vaughan Williams

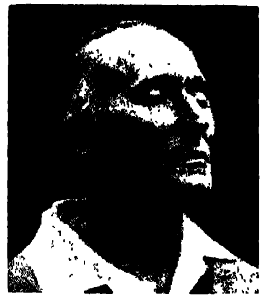
The next big figure on the musical horizon is Ralph Vaughan Williams (born 1872), who succeeded Elgar as a recipient of the much coveted Order of Merit. Vaughan Williams is soaked in the spirit of the English countryside, in its song and dance and its native speech. His career as a composer began late in his life. After writing his energetic "Sea Symphony" to words by Walt Whitman, he studied anew for a short time with Maurice Ravel and thereafter



DISTINGUISHED BRITISH COMPOSERS. Sir Arthur Sullivan, left (1842–1900), whose lyrical genius found expression in collaboration with W. S. Gilbert in light opera. Sir Hubert Parry, centre (1848–1918), did much to bring about an English musical renaissance. He is chiefly remembered for his oratorios and for his choral song "Jerusalem." Sir Charles Stanford, right (1852–1924), wrote operas and many charming songs. As a teacher of composition he was unrivalled.

ELGAR AND VAUGHAN WILLIAMS. Sir Edward Elgar, left (1857-1934), is famous for his oratorios and cantatas, including " The Spirit of England." Ralph Vaughan Williams, right (born 1872), is soaked in the spirit of the English countryside.




DELIUS AND HOLST. Frederick Delius, left (1862-1934), a romantic composer, achieved magnificent examples of nature-worship expressed in music, including " The Songs of the High Hills." Gustav Holst, right (1874-1934), was influenced by the old English composers.

found his own native idiom, the true speech of English music. He has written five more symphonies (the " London," the " Pastoral," and three without titles), several operas (including *Hugh the Drover*), and many miscellaneous works, from a piano concerto down to songs and folk-song arrangements.

Frederick Delius (1862–1934) is in a niche all by himself. A romantic composer with a strong leaning towards impressionism, Delius used the chorus almost as a new kind of orchestral instrument. " Appalachia," " The Song of the High Hills," " On hearing the First Cuckoo in Spring," are examples of his nature-worship expressed in music

Gustav Holst (1874–1934), of Swedish extraction, was influenced by the old English composers. His operas *The Perfect Fool* and *At the Boar's Head* contain beautiful ballet music. He is best known for his orchestral suite " The Planets," but two of his choral works, " The Hymn of Jesus " and the " Ode to Death," are even more beautiful.

Cyril Scott (born 1879) found a public in Europe with his piano works. Frank Bridge (1879 1941) specialised in chamber music, as did Roger Quilter (1877–1953) in songs. Peter Warlock (1894–1930) has some claim to be called the greatest English song-writer since Purcell. Constant Lambert (1905–1951), critic and ballet conductor, was the first English composer invited to write for the Russian ballet of Diaghilev, in 1926, and he made a considerable stir with his choral piece, " The Rio Grande."

Bax, Ireland, Bliss

Sir Arnold Bax (1884–1953) stood a little aside from the main British tradition. He is best known for the orchestral tone poems " Tintagel," and the " Garden of Fand," both rooted in a background of deep Celtic romance which is reflected in the shadows and half-lights of the complex orchestral texture. His choral writing, particularly " Mater Ora Filium," and " This Worlde's Joie," for unaccompanied choir, is even finer, but is less frequently heard.

John Ireland (born 1879) is one of the few English composers of his generation with a natural gift for piano writing, shown in the Piano Sonata of 1920 and a number of shorter pieces. He is also an excellent song writer, with a sensitive ear for English poetry.

Sir Arthur Bliss (born 1891) first came into prominence with his " Colour Symphony " in 1922, and reached an even wider public with his music for the H. G. Wells film *Things to Come*, and his ballets *Checkmate* and *Miracle in the Gorbals*. He became Master of the Queen's Music on Bax's death in 1953.

The first English composer to achieve a genuine international reputation in the 20th century was Sir William Walton (born 1902). From his early essay in humorous parody, " Façade," he turned to more serious work with


IRELAND AND BLISS. John Ireland, left (born 1879), with a natural gift for piano writing, is also an excellent song writer. Sir Arthur Bliss, right (born 1891), became Master of the Queen's Music in 1953. He first came into prominence with his " Colour Symphony " in 1922.

WALTON, BAX, AND BRITTEN. The first English composer to achieve a genuine international reputation in the 20th century was Sir William Walton, left (born 1902). Sir Arnold Bax, centre (1884–1953), is best known for his "Tintagel" and "The Garden of Fand." Benjamin Britten, right (born 1913), had his first opera, "Peter Grimes," produced in 1945.

the overture "Portsmouth Point." Then followed the "Symphonie Concertante" for piano and orchestra, the Viola Concerto, the magnificent oratorio *Belshazzar's Feast*, the First Symphony (1935-36), and the brilliant but more lyrical Violin Concerto.

To Walton's generation belong Edmund Rubbra (born 1901), a natural symphonic writer with a closely wrought contrapuntal style ; Lennox Berkeley (born 1903), whose clarity of style and delicacy of harmony reflect his Parisian training ; Alan Rawsthorne (born 1905), who seems to be at his best in the shorter forms and smaller instrumental combinations ; Michael Tippett (born 1905), best known for the secular oratorio *A Child of Our Time* ; Elisabeth Lutyens (born 1906), and Humphrey Searle (born 1915), who are the chief British exponents of Schönberg's twelve-tone system.

Benjamin Britten (born 1913) first made his name with a series of works (often centred round the tenor voice of Peter Pears) which appeared in the early years of the Second World War. They included settings of Donne's "Holy Sonnets," of Michelangelo's sonnets, of Rimbaud's "Illuminations," and of a group of well-known English poems in the form of a "Serenade for Tenor, Horn, and Orchestra." In 1945 his first opera, *Peter Grimes*, was produced at the Royal Opera House, Covent Garden. It was not only an immediate success, but it also opened the way for a remarkable revival in British opera.

To this revival, Britten contributed two small-scale works, *The Rape of Lucrece* and *Albert Herring*, the charming miniature *Let's Make an Opera*, and two full-scale operas, *Billy Budd* and *Gloriana*. Works by other composers which followed at Covent Garden include *The Olympians* by Bliss, *Pilgrim's Progress* by Williams, *Troilus and Cressida* by Walton, *Nelson* by Berkeley, and *The Midsummer Marriage* by Tippett.

LESSON 19

Professional and Amateur Musicians

It is generally agreed that the only practical way to learn to play a musical instrument with anything approaching professional skill is by direct individual tuition. Many private music teachers give lessons in piano, organ, violin, and cello playing, and in singing, and this system of private tuition is the basis of both professional and amateur music making. Teachers for other instruments are fewer.

During the last 30 years or so there has been a steady increase in the attention paid to music in schools. Much of this tuition is based on singing ; but many schools encourage the use of instruments at all stages. Percussion bands are popular in the youngest classes, and recorders among older children ; in secondary schools there are sometimes brass or military bands and small orchestras. Besides the making of music, musical appreciation is being taught in schools and in adult education classes ; for this, gramophone records and B.B.C. broadcasts are invaluable adjuncts.

MUSICIANS IN THE MAKING. Percussion bands are popular in the youngest classes at many schools. Witness the seriousness with which these budding musicians apply themselves to the manipulation of drums, cymbals, and triangle.

A more intensive musical education is available for selected boys in the choir schools attached to a number of cathedrals and other ecclesiastical establishments. This was for centuries the normal mode of entry into the musical profession. Since medieval times the universities have granted degrees in music which were, and still are, the recognized prelude to a career as a cathedral organist. The traditional syllabus included a considerable amount of textbook harmony and counterpoint, and called for formal compositions within the academic rules. During the 20th century the requirements have been progressively liberalised, and now include the kind of musical scholarship which is concerned with the history of music and the interpretation and editing of early texts, and is called "musicology."

Musical Training Institutions

Outside the universities the chief musical training institutions in Britain are the Royal Academy of Music and the Royal College of Music, both in London ; the Royal Manchester College of Music ; and the Scottish National Academy of Music, in Glasgow. These give tuition in the practice as well as the theory of music, including the playing of all recognized musical instruments, singing, conducting, and composition.

The Associated Board of the Royal College and the Royal Academy conducts local examinations both in Great Britain and overseas, and awards diplomas which include the well-known L.R.A.M. (Licentiate of the Royal Academy of Music) and A.R.C.M. (Associate of the Royal College of Music).

Students from the four main colleges and from municipal colleges in the large towns become teachers of music either in schools, in the colleges, or in a private capacity. Others become orchestral players, and here the range is wide. There are the big symphony orchestras—the Royal Philharmonic, the London Symphony, the London Philharmonic, the Hallé (in Manchester), the Liverpool, Birmingham, Bournemouth, Yorkshire, and Scottish orchestras. There are string orchestras of national standing like the Boyd Neel Orchestra and the Jacques String Orchestra, devoted to classical music. There are large numbers of small combinations which play light music. There are theatre orchestras, and combinations formed for film and gramophone recording.

THE LONDON SCHOOLS' SYMPHONY ORCHESTRA summer vacation course is seen in session here. The orchestra is at practice at Archbishop Tenison's Grammar School, Kennington Oval. Players taking part in the course are selected from a very large entry, membership of the orchestra for concert purposes is limited to 120, and eminent musicians coach each section.

For the amateur the two most highly organized fields of activity are the choral societies and the brass bands. The two areas where choral singing has been most closely wrapped up with the life of the community are Wales and the north of England. Welsh singing is famous, and the Huddersfield Choir has for many years ranked as one of the finest in the world.

The local choral societies support and foster the many musical festivals now held in various parts of Britain. These range from the Three Choirs Festival (Gloucester, Hereford, and Worcester), which dates from 1742, to small local activities of quite recent foundation.

There is the Welsh National Eisteddfodd; and there is a large number of other competitive festivals organized by the British Federation of Musical Competition Festivals, in which small choirs and amateurs of all ages compete. In contrast to these is the movement for non-competitive schools' festivals fostered by the Schools Music Association.

For at least a century and a quarter, amateur brass bands have been an important feature of British musical life. They came to be organized as soon as devices were invented for producing chromatic scales on the brass instruments. The first that can be traced is the Stalybridge Old Band, 1814. It was not strictly a brass band then, because it contained flutes, clarinets, and bassoons, as well as trumpet, horns, bugle horn, serpent, and percussion; but well before the middle of the 19th century the reed instruments dropped out. Other early combinations which have become famous are Besses o' th' Barn, Kingston Mills, Black Dyke, Wyke Temperance, and Leeds Forge.

The first open contest seems to have been organized by Sir Clifford Constable at a fête in the grounds of Burton Hospital, near Hull, in 1815. The first contest at Belle Vue, Manchester, was held in 1853; the first at the Crystal Palace, London, in 1860. Since then the brass-band movement has been dominated by the annual competitions. For many years almost all the music consisted of arrangements of classical pieces, operatic airs, popular songs, and military marches. In 1913 a scheme was started to improve the standard, by commissioning test pieces from composers of note. In this way pieces by Elgar, Holst, Ireland, Bantock, Hubert Howells, Sir Arthur Bliss, and others have been added to the repertoire.

The modern brass band consists of valved instruments and trombones up to 24 in number. Parts are written for soprano cornet, B flat cornets, flügelhorn, tenor horns, baritones, euphoniums, tenor and bass trombones, and E flat and B flat bombardons. The result is a peculiarly smooth and even silky ensemble, capable within its own range of a surprising variety of tone colour, and suited equally to the rousing brilliance of a military march and the sustained harmonics of a Bach chorale.

The military band contains woodwind and percussion as well as brass instruments. It has its own repertoire of strictly military music, as well as a considerable range of adaptations. British military bands have held a high place in European esteem ever since the latter half of the 18th century. The army runs a school for bandsmen (the Royal Military School of Music) at Kneller Hall, Twickenham, Middlesex. The Royal Navy has a similar institution at Portsmouth. The R.A.F. does not train its own musicians, but recruits them direct.

BOOK LIST

General. *Grove's Dictionary of Music and Musicians* (9 vols), ed. Eric Blom (Macmillan); *The Oxford Companion to Music*, Percy A. Scholes (O.U.P.); *The World of Music*, ed. K. B. Sandved (Waverley); *Music*, W. H. Hadow (O.U.P.).

History. *A History of Music*, C. V. Stanford and C. Forsyth (Macmillan); *The Growth of Music*, H. C. Colles (O.U.P.); *The New Music*, George Dyson (O.U.P.); *The Heritage of Music* (Essays on Great Composers), ed. Hubert J. Foss (O.U.P.); *Studies of Great Composers*, C. Hubert H. Parry (Routledge); *The Books of the Great Musicians*, P. A. Scholes (O.U.P.); *Studies in Modern Music*, W. H. Hadow (Seely, Service); *History of English Music*, E. Walker (O.U.P.); *A History of Music in England*, E. H. Fellowes (O.U.P.); *English Music*, W. H. Hadow (Longmans); *The English Madrigal Composers*, E. H. Fellowes (O.U.P.); *Foundations of English Opera*, E. J. Dent (O.U.P.); *Some English Symphonists*, D. F. Tovey (O.U.P.); *British Music of Our Time*, A. L. Bacharach (Pelican).

Theory. *Structure of the Musical Scale*, John L. Dunk (Lane); *The Structure of Music: an Outline for Students*, R. O. Morris (O.U.P.), *Melody and Harmony for the Teacher and Student*, Stewart Macpherson (Williams); *Orchestration*, C. Forsyth (Macmillan; Stainer & Bell); *Orchestral Technique: a Manual for Students*, Gordon Jacob (O.U.P.); *How to Compose Music*, H. Baynton-Power (Pitman).

Singing. *Voice and Verse: a Study in English Song*, H. C. Colles (O.U.P.); *Interpretation in Song*, H. Plunket Greene (Macmillan); *Singing: the Art and the Craft*, W. S. Drew (O.U.P.); *Opera*, E. J. Dent (Pelican).

Instruments. *The Orchestra and its Instruments*, H. J. Wood, H. C. Hind, and E. Evans (Boosey and Hawkes); *Orchestration*, C. Forsyth (Macmillan; Stainer & Bell); *The Orchestra Speaks*, B. Shore (Longmans); *Organ Playing*, P. C. Buck (Macmillan); *Piano Technique. Foundation Principles*, James Ching (Murdoch); *Pianoforte Playing*, Tobias Matthay (Longmans); *Violin Technique*, S. Robjohns (O.U.P.); *The Instruments of Music*, R. Dennington (Methuen).

Church Music. *Music and Worship*, Walford Davies and Harvey Grace (Eyre & Spottiswoode); *English Cathedral Music*, E. H. Fellowes (Methuen).

Appreciation. *Intelligent Listening to Music*, W. W. Johnson (Pitman); *The Listener's Guide to Music*, P. A. Scholes (O.U.P.); *Discovering Music: a Course in Musical Appreciation*, H. D. McKenney and W. R. Anderson (Dobson); *Design in Music*, G. E. H. Abraham (O.U.P.); *Essays in Musical Analysis*, D. F. Tovey (O.U.P.); *The Orchestra and How to Listen to it*, M. Montague Nathan (Kegan Paul).

PHYSICAL GEOGRAPHY

PHYSICAL GEOGRAPHY *is the explanation in general terms of the natural phenomena which, in differing combinations, make up the particular geography of the different regions of the world. As seen in this Course, it includes what is known about the position of the earth in space; about the surface of the earth and its nature, and how measurements are made on it and maps of it constructed; about the weather conditions that affect the earth; and about rivers, oceans, and glaciers and their behaviour.*

Knowledge of the underlying principles of physical geography is a desirable preliminary to the study of REGIONAL GEOGRAPHY, *in Vol. 2, and the Course which here follows is intended to give the student the necessary elementary insight into the subject. It is recommended that it should be read also in conjunction with the Course on* ECONOMIC GEOGRAPHY *in Vol. 3. Fuller information on certain of the phenomena affecting physical geography will be found in the Course on* GEOLOGY *in this volume.*

12 LESSONS

LESSON 1

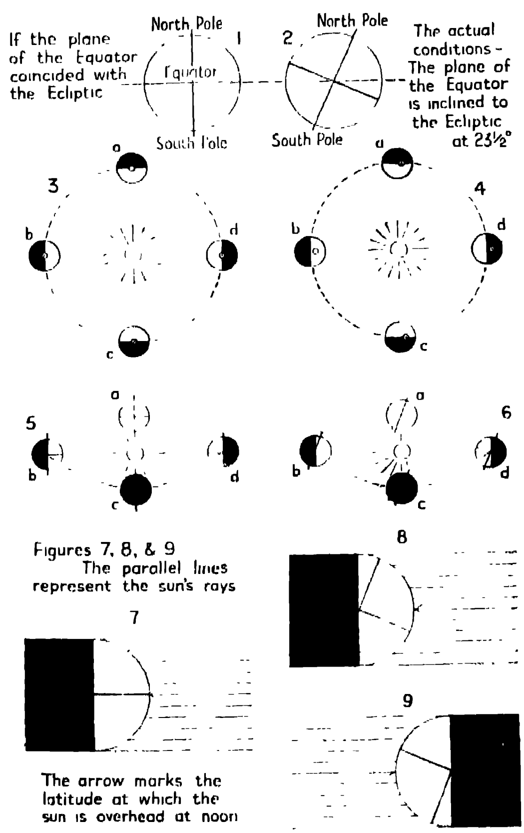
The Earth and its Position in Space

THE earth is a sphere, revolving round the sun. A familiar illustration of its spherical shape is that of a ship near a lighthouse set on a steep rocky coast: to an observer on the ship, the top of the lighthouse appears first. As the ship nears the coast, the whole of the lighthouse and then the cliff down to the waterline gradually become visible. Another illustration is the circular shadow of the earth during an eclipse of the moon.

If the earth were a true sphere, its equatorial diameter (a straight line connecting two points on the equator, and passing through the centre of the earth) would be equal to its polar diameter (a straight line joining the north and south poles). But this is not so: the earth is slightly flattened at the poles.

A pendulum clock is regulated by lengthening the pendulum (to make the clock go more slowly), or by shortening it (to make it go faster). In 1672 the French astronomer Jean Richer found that a clock which kept accurate time in Paris (49° N. Lat.) lost two minutes a day at Cayenne (5° N. Lat.). Sir Isaac Newton explained in 1687 that this was due to the fact that a pendulum swings faster the nearer it is to the centre of the earth. As the clock lost time at Cayenne (in French Guiana), that place must be farther from the centre of the earth than Paris. This can be explained by the conclusion that the farther a place is from the equator, the shorter will be the earth's radius measured at that point. As a fact, the equatorial diameter is 7,926 miles, 27 miles longer than the polar diameter (7,899 miles), and the earth is really *spheroidal* in shape.

The earth has two principal movements: (1) it revolves round the sun once in a year and a few hours, moving in an anti-clockwise direction; (2) it rotates on its polar axis once in 24 hours, in a direction which can be described by saying that the place in which you live travels east.



EARTH'S MOVEMENTS. Figs. 1-9. Illustrating the plane of the equator and the ecliptic.

The Ecliptic

The earth's path round the sun is not a circle but an ellipse, with the sun in one of the two foci, so that there will be a point of the earth's closest approach to the sun (perihelion) and, six months later, the point of its greatest distance (aphelion). The ellipse is so nearly a circle that the difference between the earth's distances from the sun at perihelion and aphelion is only about one-sixtieth of the greater diameter of the earth's orbit.

The only effect of this difference on the climate is to make the summers in the southern hemisphere slightly warmer than those in the northern hemisphere. It is the annual motion which really affects the climate. Not only does it give those variations of temperature at different parts of the year, called seasons, but it also produces the varying relative length of day and night at different times of the year.

The plane in which the earth travels round the sun is called the *ecliptic*. If the earth's axis were perpendicular to the ecliptic, the plane of the equator would always coincide with the ecliptic (Fig. 1); no point of the equator would ever be above or below the ecliptic. This is not the case, as the plane of the equator is inclined to the ecliptic at an angle of 23½° as shown in Fig. 2.

In order to get the conditions resulting from this quite clear, consider first what the conditions would be if the plane of the equator *did* coincide with the ecliptic. These conditions are illustrated

by the four left-hand diagrams; the five on the right show the conditions arising from the inclination of 23½° which has just been referred to.

Assuming that the earth's axis is perpendicular to the ecliptic, it must, when viewed, as it were, from above (Fig. 3), point directly at the observer, and the point on the earth's surface nearest to him will be the North Pole, marked in the diagram by a dot within a circle. For present purposes it will suffice to examine only four positions of the earth on its annual journey round the sun.

Fig. 5 is what may be called a side view, drawn in perspective. Both Figs. 3 and 5 show the same thing—that the sun, under the conditions being considered at present, will always be overhead at noon to an observer on the equator, and that the line on the earth's surface dividing day and night will always pass through the poles.

In position *a* of Fig. 5 only that half of the earth which is turned to the sun is seen, and is illuminated; in position *c* only the other (dark) hemisphere is seen. The conditions shown, on a larger scale, in Fig. 7 would exist all the year round in the imaginary conditions which, for the sake of the argument, are being assumed.

The right-hand diagrams illustrate the actual conditions, with the earth's axis tilted at 23½°, as shown in Fig. 2. A comparison of the position of the North Pole in Figs. 4 and 6 with that in Figs. 3 and 5 will make it clear that only in positions *a* and *c*, and only on two days in the year, will the dividing line between day and night pass through the poles, giving the conditions shown in Fig. 7. In position *b* the sun's light travels beyond the North Pole, leaving the South Pole in the dark (Fig. 8). In position *d* the South Pole has daylight, while the North Pole is in the dark (Fig. 9).

LESSON 2

Latitude and Longitude

The position of any place on the globe can be stated by naming its latitude and longitude. On any atlas map the lines drawn from west to east are parallels of latitude; those drawn from north to south are called meridians of longitude.

In Fig. 10 are two pieces of paper, M and N, ruled in squares. On M is marked a point X. You can mark a point X^1 in the same position on paper N by counting 5 intervals from A to E, and 6 intervals from E to X^1. That is exactly what one does in fixing the position of a place on the globe by its latitude and longitude. EX represents latitude north of AB, and AE represents longitude east of the meridian AD.

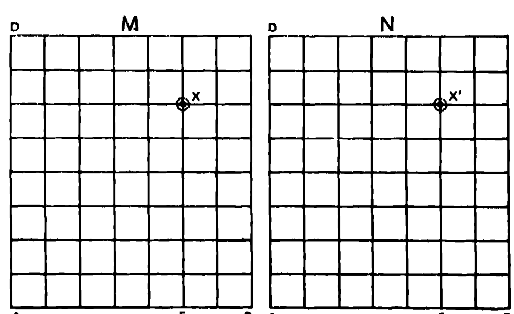
Parallels of Latitude

The angle formed by the polar diameter and any radius of the equator is a right angle (90°). Divide this angle into 9 equal parts (10° each), and produce the dividing lines to the surface of the globe. Through the ends of these lines draw circles round the globe, parallel to the equator. These are the parallels of latitude, and all points on any one of them will be the same distance from the equator, measured along the meridians passing through them. The larger a globe or map is, the more parallels of latitude can be drawn on it, at intervals of 10°, 5°, or even 1°, and the more accurately can one locate a place in its correct latitude, either by eye or by actual measurement between the two nearest parallels. Latitude is stated in degrees, minutes, and seconds, N. or S., from the equator (0°) to the two poles (90°), 60 seconds being equal to one minute, 60 minutes to one degree.

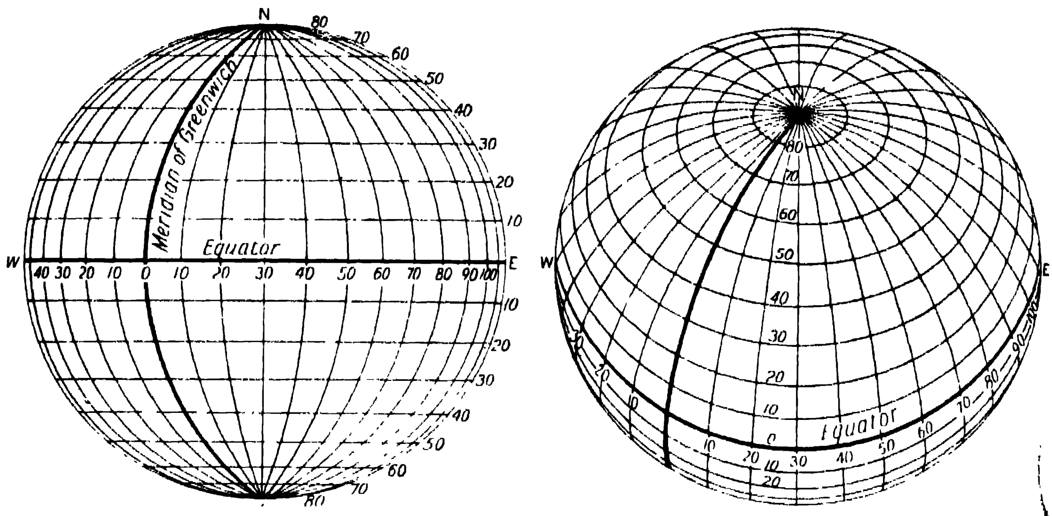
In addition to the parallels of latitude drawn at varying intervals according to the scale of the globe or map, four others play an important part in connexion with the changes of the seasons, and the varying relative length of day and night.

It has already been shown that the earth's axis is not vertical to the ecliptic but is out of the perpendicular by 23½°, with the result that twice during the year the sun is overhead at noon to an observer either 23½° north or 23½° south of the equator. When this occurs, the sun appears to be in one or other of the constellations Cancer and Capricorn. Hence the two parallels 23½° north and south of the equator are named respectively after these two constellations.

When the sun is overhead at the equator, the dividing line between day and night passes



LATITUDE AND LONGITUDE. Fig. 10.
Showing principle of calculation as explained in this page.



PARALLELS OF LATITUDE AND MERIDIANS OF LONGITUDE. Fig. 11. The parallels of latitude are numbered north and south from the equator, which is 0. The meridians of longitude are numbered east and west of that of Greenwich, which is 0. (Right) Looking down slantingly on the northern half of the globe. These two diagrams show only every tenth parallel and meridian.

through the poles (Fig. 4). When it is overhead at one of the tropics (Figs. 8 and 9), that dividing line will pass through two points $23\frac{1}{2}°$ from the poles. The two parallels of latitude drawn through these points are called the Arctic (north polar) circle and the Antarctic (south polar) circle.

Astronomical Observation

The latitude of a place can be determined by astronomical observation. The Pole Star (Polaris) is a fixed star only $1\frac{1}{2}°$ from a line continuing the earth's axis beyond the north pole. It is at such an enormous distance from the earth that to two observers placed as far apart as possible on the earth, namely, at opposite ends of an equatorial diameter, it appears in the same direction. For the same reason, the $1\frac{1}{2}°$ referred to may be disregarded and the Pole Star taken to be exactly over the North Pole. To an observer looking north from any point on the equator, the Pole Star appears low down on the northern horizon.

If he travels north, the Pole Star will appear to rise above the horizon, until, when he reaches the pole, it will be overhead. As the latitude of the North Pole is 90°, this means that the star has appeared to rise one degree for every degree of latitude travelled by our observer from the equator (0°) to the pole (90°). Consequently the latitude of any place on the northern hemisphere can be determined by observing the height above the horizon, or "altitude," of the Pole Star. On the southern hemisphere, latitude is determined by similar observation of two stars in the constellation Southern Cross.

Latitude indicates the distance of any place on the earth from the equator in degrees measured along a meridian. As it counts from the equator, 15° north latitude means the same thing whether on a British or on any other map.

Longitude

Longitude is the distance east or west of any given meridian. As the number of meridians which it is possible to draw on a globe is theoretically infinite, to avoid confusion the meridian of the Greenwich observatory has been fixed upon by the countries of the world, with very few exceptions, as the meridian of 0° of longitude, and distances are measured east and west up to the meridian of 180° on the opposite side of the earth.

Look at any map in an atlas, and it is seen that the degrees of longitude are numbered in such a way (along the top and bottom of the map) that the figure "0°" will fall on the Greenwich meridian, which is called the primary or standard meridian.

All parallels of latitude, as well as the equator, can be divided into 360 degrees, so that although obviously the length of a degree of longitude becomes smaller the farther it is from the equator, the number will always be the same. This means that it is possible to measure longitude either along the equator or along a parallel of latitude.

The daily rising and setting of the sun is only an apparent movement, produced by the rotation of the earth from west to east. An observer placed at Greenwich at noon will see

the sun due south of that point. Twenty-four hours later, at noon on the following day, he will again see the sun in the same direction. In 24 hours the earth, in making one rotation, has carried the observer through all the 360° of a full circle; and 360° in 24 hours means 15° in one hour, and 1° in 4 minutes.

Greenwich Time and Local Time

From this follows an interesting result. An observer at a place X, 15° east of Greenwich, will see the sun in the south an hour earlier than the observer at Greenwich: when it is noon at Greenwich, it will be already 1 p.m. at X. At a place Y, 15° west of Greenwich, it will not be noon till it is already 1 p.m. at Greenwich.

This explains what is meant by Greenwich time and local time, and the figures given will enable the student to work out for any given time at Greenwich the local time of any place of which he knows the longitude. Difference in longitude tells the difference of time.

Fig. 12 is a map of the world on Mercator's projection. Along the top are given the longitudes east and west of Greenwich at 15° intervals. Along the bottom is local time at the various longitudes when it is noon at Greenwich.

Determining Longitude by Time

Difference of longitude tells difference in time; and therefore difference in time will tell difference of longitude. If an observer at any place is in a position to compare local time with Greenwich time, he can quite easily work out his longitude.

This comparison can be made by means of a clock or watch (chronometer) which keeps Greenwich time, or by means of a time signal, transmitted by cable or wireless, which tells the observer, to the fraction of a second, when it is noon, or any other time, at Greenwich. Longitude can also be determined by astronomical observations.

The student may recall how the hero of Jules Verne's romance *Round the World in Eighty Days* nearly lost his bet because he forgot that by travelling from west to east he had gained a day. If he had travelled in the reverse direction, he would have lost a day. The explanation is as follows:

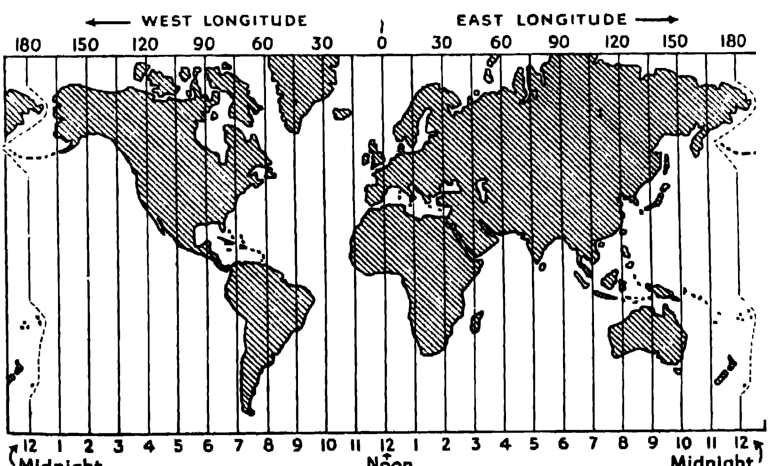
Two travellers, A and B, start from Greenwich in opposite directions, to travel round the globe. They meet on a small island in the Pacific, situated on the meridian of 180°, when by Greenwich time it is midnight between a Tuesday and a Wednesday. Local time is noon (180° — 12 hours), but traveller A, who has come from the west, will call it noon on Wednesday (12 hours in advance of Greenwich time), while traveller B, who arrived from the east, will be equally certain that it is noon on Tuesday (12 hours behind Greenwich).

In order that A may not gain a day (like Jules Verne's traveller), he must, on continuing his voyage, go back to noon on Tuesday, so that the 24 hours between Tuesday noon and Wednesday noon will appear twice over in his diary. Similarly, in order that B may not lose a day, he must go right on to noon of Wednesday, so that the period between Tuesday noon and Wednesday noon will not appear in his diary at all.

International Date Line

It should be added that the line (the International Date Line) at which the captain of a ship going round the world has to change the date in his log is not the same throughout as the meridian of 180°. It is deflected to avoid the inconvenience that would arise if two islands within a few miles of each other had different dates.

If each town kept to local time, there would be confusion in the railway time-tables, and travellers would always be too early or too late for their trains. To avoid this, local time is arranged by zones. Great Britain, the Irish Republic, Belgium, and France use Greenwich time as the basis of local time; for



MERIDIANS OF LONGITUDE. Fig. 12. Map of the world on Mercator's projection. Note how the (dotted) International Date Line is deflected to the east of New Zealand and Fiji and to the west of the Aleutian Islands.

Germany, Switzerland, Italy, and Hungary, basic local time is that of 15° east of Greenwich (noon at Greenwich = 1 p.m. in Berlin). In Canada and the U.S.A. there are five time-zones of 15° each, in which noon is respectively 4, 5, 6, 7, and 8 hours later than at Greenwich. Beginning with Great Britain in 1916, many countries have adopted measures by which local time is in advance of sun time during part of the year. Calculations to determine longitude must be based on true local time (i.e. sun time) and not on "summer time."

LESSON 3

What the Sun Does for the Earth

In the first Lesson of this Course it was explained how the distribution over the earth's surface of the light and warmth received from the sun is affected by the fact that the axis round which the earth rotates is not vertical to the ecliptic, but is out of the perpendicular by an angle of 23½°. This was illustrated by diagrams showing the conditions at four points of the earth's path round the sun. Fig. 13 illustrates those conditions for approximately the 21st day of each month of the year. As in Figs. 7, 8, and 9, the parallel lines represent the sun's rays ; the arrowhead indicates the latitude at which the sun is overhead at noon.

The Seasons

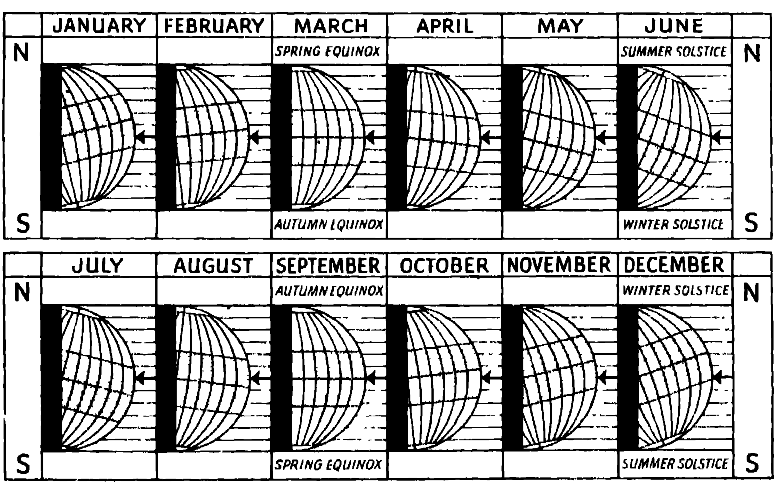
The four positions shown in diagrams 7, 8, and 9 refer to the days in March and September when the sun at noon is overhead at the equator, and to the days in June and December when it is overhead at noon on the tropics of Cancer and Capricorn respectively. It appears, then, that the two tropics represent the farthest latitude from the equator at which the sun is ever overhead, so that during the remaining eight months the sun is overhead at latitudes lying between the two tropics. This area, to which, as to the two parallels which enclose it, the term tropics can be applied, is marked in the diagrams by a light stipple.

Solstice, from a Latin word signifying the standing still of the sun, is the time at which the sun, having reached the farthest point north or south of the equator at which it is ever overhead, appears to stand still before turning back towards the equator. This turning back explains the meaning of the word *tropic*, which is derived from the Greek word for to turn. The letters N and S in the diagrams refer to the northern and southern hemispheres.

Two factors affect the amount of warmth reaching a given point on the earth's surface. The sun's rays lose heat during their passage through the atmosphere. The longer that passage is, the more heat will they lose. Vertical rays, having the shortest distance to travel through the atmosphere, will bring most warmth.

When a heat-bringing ray strikes a flat surface vertically, it has a smaller area to warm than if it comes at an angle. Consequently that portion of the earth's surface will receive most warmth where the sun is overhead ; the farther away an area is from that point, the less will be the amount of warmth reaching it.

If, as the diagrams show, it is winter in the northern hemisphere when it is summer in the southern, and vice versa, the same reversal will obviously apply to the intermediate seasons of spring and autumn. This brings one to a consideration of the two days in the year on which the sun at noon is overhead at the equator, these days being styled



SUN AND THE SEASONS. Fig. 13. The four seasons are determined by the latitude at which the sun is overhead at noon. In these diagrams the horizontal lines represent the sun's rays. The stippled areas lie between the tropics of Cancer and Capricorn, the farthest latitudes north and south of the equator at which the sun is ever overhead at noon, a position marked in these diagrams by the arrows.

the spring and autumn equinox (= equal night). For this purpose it must first be noted that the actual movement round its axis of the earth produces an apparent movement of the sun, which can be observed and followed any day, namely, that of rising in the eastern heavens, passing across the sky, and setting in the western heavens.

The sun rises at or very near the east point of our horizon on the day of the equinox, when, on its apparent path round the earth, it has to traverse 180° in 12 hours. Omitting astronomical detail, it can be said that on the shortest day its path will be shorter, on the longest day it will be longer. Within these limits the sun will rise at a different point each day, so again the winter and summer solstices are marked by an apparent standing still (solstice) and turning back (tropic).

Day and Night

The meridians in our pictures of the earth are drawn at intervals of 15°, so that the sun, in its passage over one of these intervals, will be giving one hour's daylight to the earth. Our diagrams, being flat, show only one half of the earth's illuminated surface. Such diagrams cannot be used for ascertaining the exact length of day or night on various dates, but they are sufficiently accurate to illustrate general principles.

By counting the number of 15° intervals shown as illuminated, doubling that number (to include those not visible in the diagram), and remembering that the counting must be done along the parallel of latitude at which the sun happens to be overhead at noon, the student will now, with no further help beyond the diagrams themselves, be able to find the explanation of the following phenomena.

1. Day and night on the equator are equal all the year round.
2. Day and night are equal all over the globe on two days only, spring and autumn equinox.
3. The summer solstice, both north and south, brings the longest day and shortest night.
4. The winter solstice, both north and south, brings the shortest day and longest night.
5. Twice a year day and night are equal within the polar circles, as they are all over the globe. But once a year there is a 24-hour day, and once a year a 24-hour night, within each polar circle.

LESSON 4

Distribution of Land and Water

In Lesson 3 it was explained how the actual movement of the earth produced an apparent movement of the sun, and how this resulted in distributing the sun's warmth over the surface of the globe in such a way as to enable us to divide the year into certain periods, called the seasons. This would appear to show that the distribution of the sun's warmth depends wholly on latitude, the areas nearest to a latitude at which the sun was overhead receiving most warmth, while the farther away an area from that latitude the less warmth would it receive. Such, indeed, would be the case if the earth's surface were all land or all sea, without differences of height and depth.

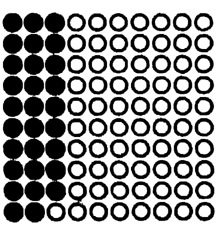


Fig. 14. Proportion of land and water shown by black and white disks.

That the distribution of temperature over the globe is very considerably affected by circumstances other than latitude can be made clear by a single example. The Strait of Belle Isle, separating Newfoundland from the southern end of the Labrador coast, is in the latitude of London. This means that the British Isles are in the same latitude as the coast of Labrador, which is generally icebound for several months during the winter. This and other similar instances are due to three circumstances: the irregular distribution of land and sea over the globe, ocean currents, and differences in height of the land above sea level.

The total area of the globe has been calculated at 197,000,000 square miles, of which 29 per cent. (57,000,000) is land, the remaining 71 per cent. (140,000,000) water, as illustrated by Fig. 14. That even this small amount of land is not in any way evenly distributed is apparent in two maps showing the hemisphere which has most land and that which has most water (*see* Figs. 15a and 15b).

Land and Water Hemispheres

The land hemisphere contains Europe, North America, Africa, practically the whole of Asia, and most of South America; in the water hemisphere are Australia, the eastern Archipelago, the Antarctic continent, and the narrow southern end of South America.

As regards latitude, the distribution of land is very uneven, as illustrated by Fig. 16, which shows (in black) the area of land in each of the 18 ten-degree zones from pole to pole. By far the larger proportion of land (North

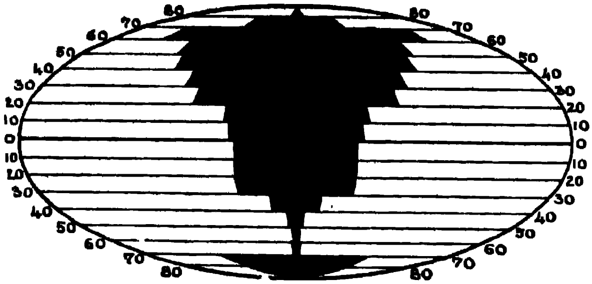


Fig. 16. Distribution of land from pole to pole. The greater proportion of it lies north of the equator.

America, Europe, Asia, and North Africa) lies north of the equator ; to the south of that line, even Australia and the Antarctic continent do not suffice to rectify the adverse balance due to the narrowing, at their southern extremities, of South America and Africa. The vast extent of the southern ocean, especially between 40° and 60° south latitude, is shown.

High Land and Deep Sea

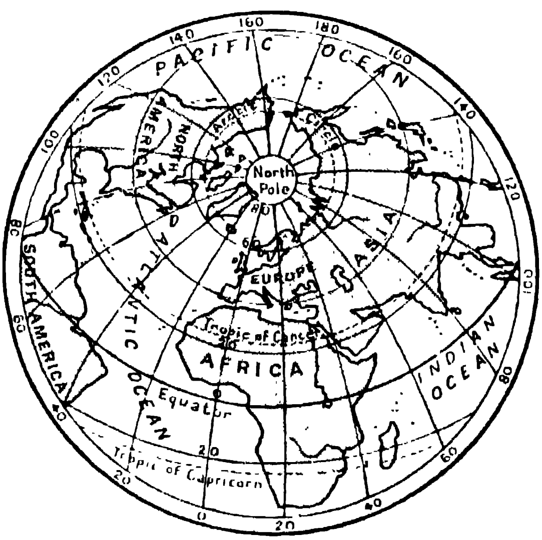
No less striking are the irregularities found in the earth's surface, and in the distribution of high and low land, and of deep and shallow sea. In Fig. 17 the seven continents are represented by seven circles. In each of these the black centre shows the area more than 6,000 feet above sea level. The white rim is land up to 600 feet above sea level. The dotted area, within which stand the seven continents, is sea less than 600 feet deep. The broad, black rim surrounding the whole stands for sea more than 6,000 feet deep, amounting to more than half the total surface of the earth. Thus Fig. 17 brings out clearly certain characteristic differences in the physical geography of the separate continents.

Fig. 18 is a *hypsographic curve*, showing the relative amount of land and water at various heights and depths. Starting from the greatest measured sea depth (35,410 feet in the Pacific, off Mindanao), the curve rises sharply to what is really the main floor of the ocean. As this floor rises to a depth of only 6,000 feet, its slope again becomes steeper (compare also Fig. 17). At the 600 feet line is the so-called continental shelf (dotted in Fig. 17), in the shallow waters of which are carried on most of the world's great fisheries, such as those in the North Sea and on the Newfoundland banks.

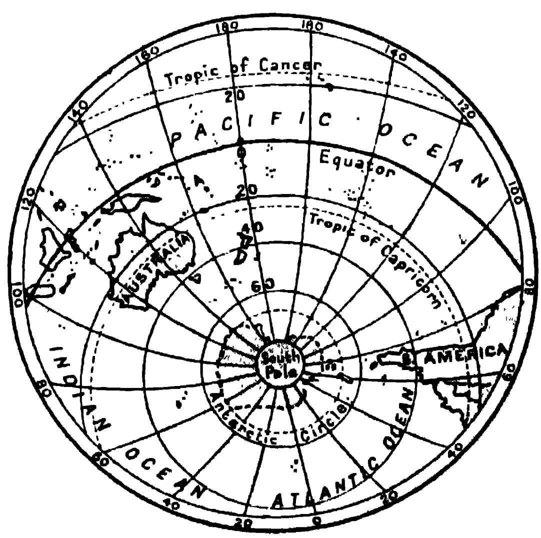
The Greatest Height of Land

Between sea level and 600 feet above it are the great lowlands, on which live a very large proportion of the peoples of the world. The slope steepens more and more as it reaches 6,000 feet above sea level, to culminate in Mount Everest (over 29,000 feet), the greatest height of land. The six squares appearing on the right of Fig. 18 show the comparative area of land surface and sea floor at the various heights and depths referred to. The enormous extent of very deep sea is illustrated in this diagram.

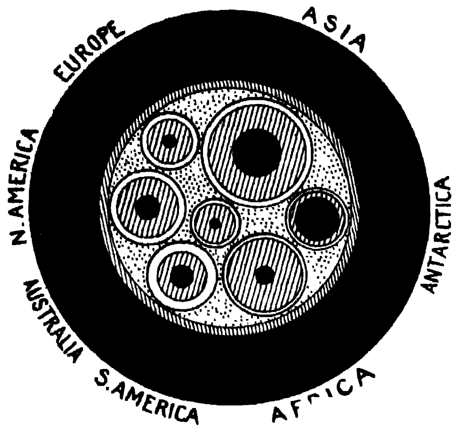
The diagrams in Fig. 19 repeat in a different way the information contained in Fig. 17, so



LAND HEMISPHERE. Fig. 15a. All the continents except Australia are contained, or almost contained, in this hemisphere.



WATER HEMISPHERE. Fig. 15b. This hemisphere comprises the greater proportion of the world's oceans.



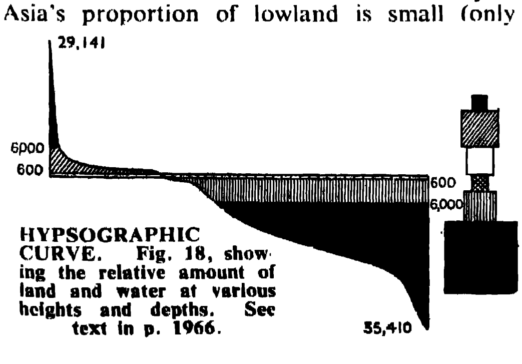
LAND AND WATER. Fig. 17. Seven continents are shown by circles. Dotted area indicates shallow seas : shaded ring, water of medium depth : broad black rim, deep seas.

far as it refers to the six continents (i.e. excluding Antarctica). While taking no account of their relative sizes, it shows, for each continent, the proportion of land in each of the three belts of height above sea level ; up to 600 feet (white), 600 to 6,000 feet (shaded), and above 6,000 feet (black).

Continental Lowlands and Highlands

Europe is the only continent of which more than half is lowland. This is accounted for by the plain of northern Germany and Russia. As this plain, especially in the west, is one of nature's great storehouses of mineral wealth, with easy communications in all directions, the fact that northern France, Belgium, and central Germany from west to east, together with part of the British Isles, form one of the world's most densely populated and most highly developed industrial regions, is sufficiently explained.

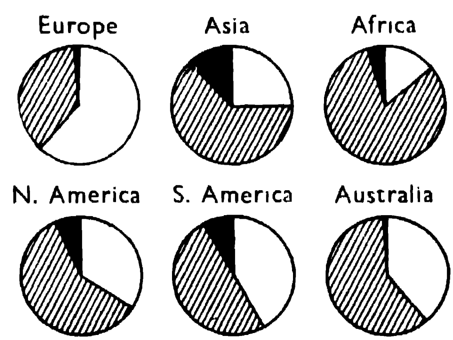
Asia has by far the largest proportion of the highest land (over 6,000 feet) in the shape of the belt of upland extending from Asia Minor eastward through Persia into central Asia, where it includes Tibet and the Himalayas. Asia's proportion of lowland is small (only Africa has less) because a great part of the northern plain lies above the 600 feet line. This northern plain and the central tableland are sparsely peopled, but the dense population of the Ganges valley and of the river valleys and lowlands of eastern China helps to bring the population of the Indian sub-continent and China together to about three-quarters of Asia's 1,290 odd millions.



HYPSOGRAPHIC CURVE. Fig. 18, showing the relative amount of land and water at various heights and depths. **See text in p. 1966.**

Africa is largely a plateau continent. Its percentage of lowland is barely one-quarter of that of Europe ; four-fifths of its area lies between 600 and 6,000 feet. African rivers, being mostly rivers of the plateau, descend sharply to the narrow coastal plain, so that their lower courses are much interrrupted by rapids, often within only a few miles of the coast. Africa's very high land is of small extent. Only Europe and Australia have a smaller proportion.

North and South America do not differ much in the extent of their very high land, as to which they come next after Asia. South



HEIGHT OF LAND. Fig. 19. Up to 600 ft. shown white ; between 600 and 6,000 ft. shaded ; over 6,000 ft. black.

America has the larger proportion of lowland (Amazon Basin, Argentina). North America's plains, the prairies of Canada and the U.S.A., lie almost entirely above the 600 feet line. Much of South America's very high land lies within the tropics, but its elevation has a moderating influence on the climate and makes this region, for its height above sea level, very densely populated.

Australia so far as its western half is concerned, is another plateau, with well over half its area between 600 and 6,000 feet. The central lowland keeps its proportion of land between these two down to about three-quarters of that of Africa. Australia's proportion of land over 6,000 feet is under one per cent. The highest summits are those of the Great Dividing Range, a mountain system in the south-east of the continent, where Mt. Kosciusko, in New South Wales, rises over 7,328 feet.

LESSON 5

The Chief Factors in Climate

THE chief factors in climate are the variations, at different times of the year, and in different regions, of temperature, atmospheric pressure, winds, and rainfall. Dealing with these four factors in the order given here, it can be shown how temperature affects the distribution of atmospheric pressure as recorded by the barometer. Pressure affects the direction and strength of the prevailing winds, which in turn are responsible for the distribution of rainfall.

Variations of Warmth

In Lesson 3 it was seen that the amount of warmth reaching a particular area of the earth's surface varies according to the latitude at which the sun is overhead at noon. Were the earth's surface all land or all sea, variations of warmth would depend on latitude only. But land is heated more quickly than water, because it is heated at the surface only. Water is heated more slowly than land, because the warmth spreads through the whole mass. Therefore land radiates more heat, because it absorbs less ; water radiates less heat, because it absorbs more. The result is that land cools fairly quickly and water cools fairly slowly.

It is well known that climbers, balloonists, and aircraft pilots often suffer severely from cold at high elevations. Thus it is evident that temperature is dependent not only on latitude and irregular distribution of land and sea but also on height above sea level.

Temperature is generally expressed on a map by means of isotherms, i.e. lines of equal warmth, drawn so as to connect all points having one and the same temperature, the lines being more or less numerous according to the scale of the map. By means of isotherms can be shown the temperature in a given region at any particular time, and the distribution over that region of the average temperature for a long or short period.

Before drawing the resulting isotherms on the map, it will be necessary to introduce a rather important modification in the temperature figures. If account were taken of such differences of temperature as exist between the summits of the Himalayas and the plain of the Ganges, or between the plateau within the Rocky Mountains and the prairies lying east of them, the map would be so crowded with detail as to be useless.

Distribution of Temperature

On average, temperature decreases by 1° Fahrenheit for every 300 feet rise in elevation. If, therefore, to the temperature recorded by the thermometer at an elevated station, 1° F. is added for every 300 feet of its height above sea level, the temperature recorded at the station is converted or, to use the technical term, reduced to sea-level temperature.

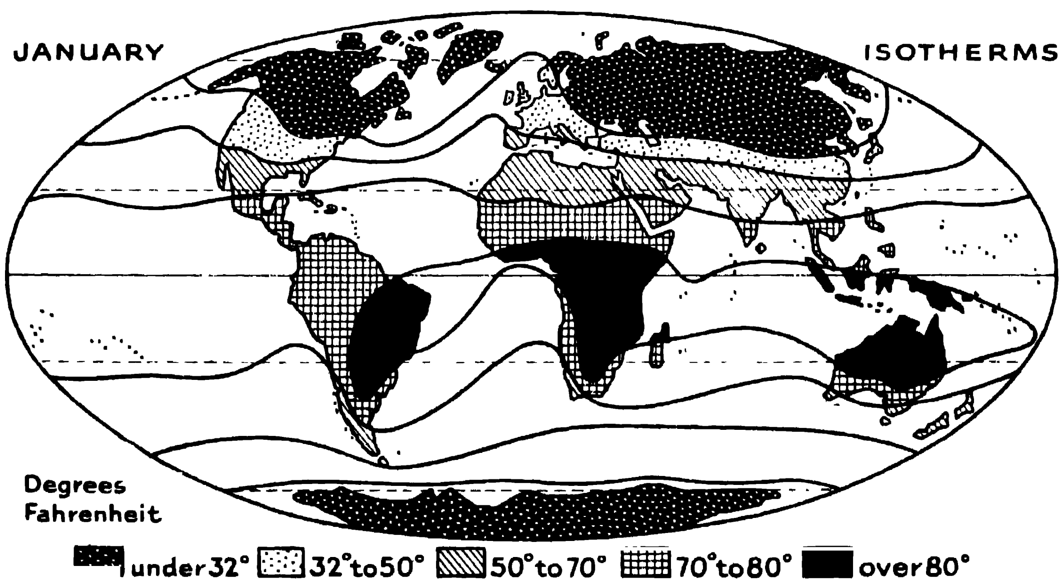


Fig. 20. AVERAGE TEMPERATURES over the earth's surface during January.

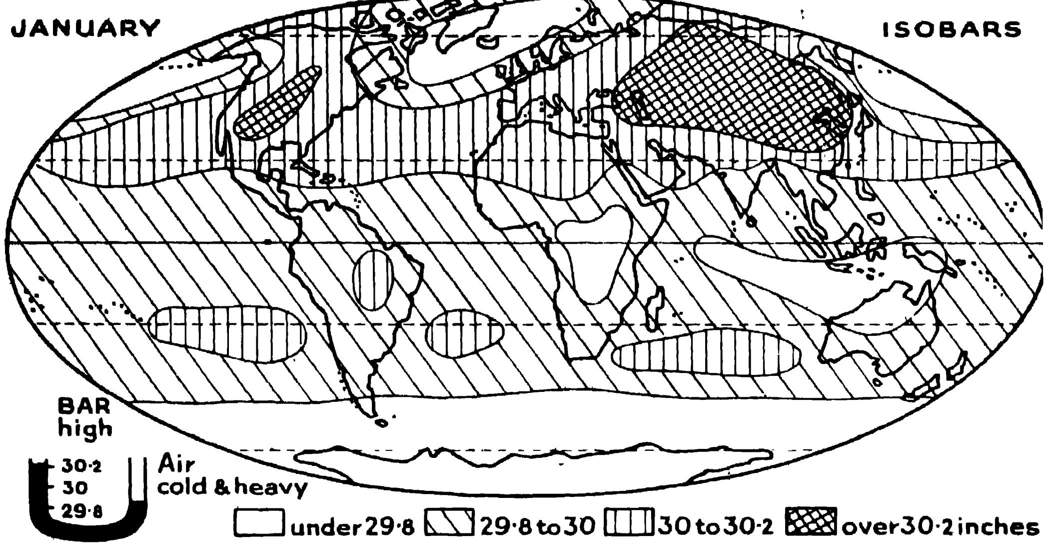


Fig. 21. AVERAGE ATMOSPHERIC PRESSURE over the earth's surface during January.

These reduced temperatures are those recorded on our maps, and on which the isotherms are based. The final result takes the form of the two maps or charts, Figs. 20 and 20a, which show the mean, or average, temperature over the earth's surface during January and July. Needless to say, over the land, particularly on mountains and high plateaux, the distribution of temperature at the ground surface will often be completely different from that given on these maps (Figs. 20 and 20a) as average.

If temperature were dependent on latitude alone, the isotherms, the lines of equal temperature, would run round the globe parallel to the equator. The maps give a very different picture. In January (southern summer) and again in July (northern summer) the isotherms of 80° F. are closer together over the sea than over the land, which means that the hottest area is more extensive on land than at sea. For

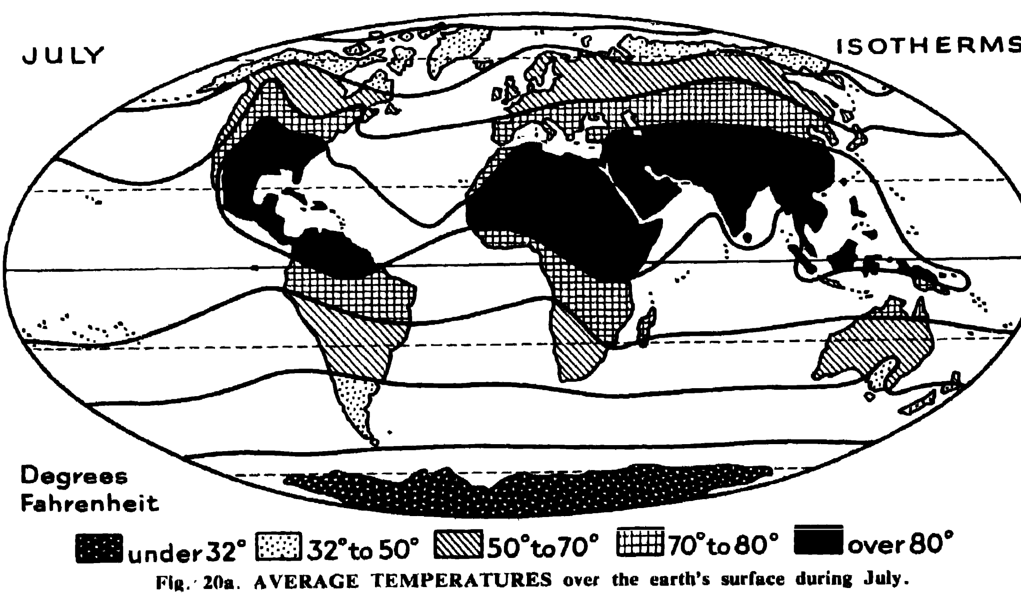


Fig. 20a. AVERAGE TEMPERATURES over the earth's surface during July.

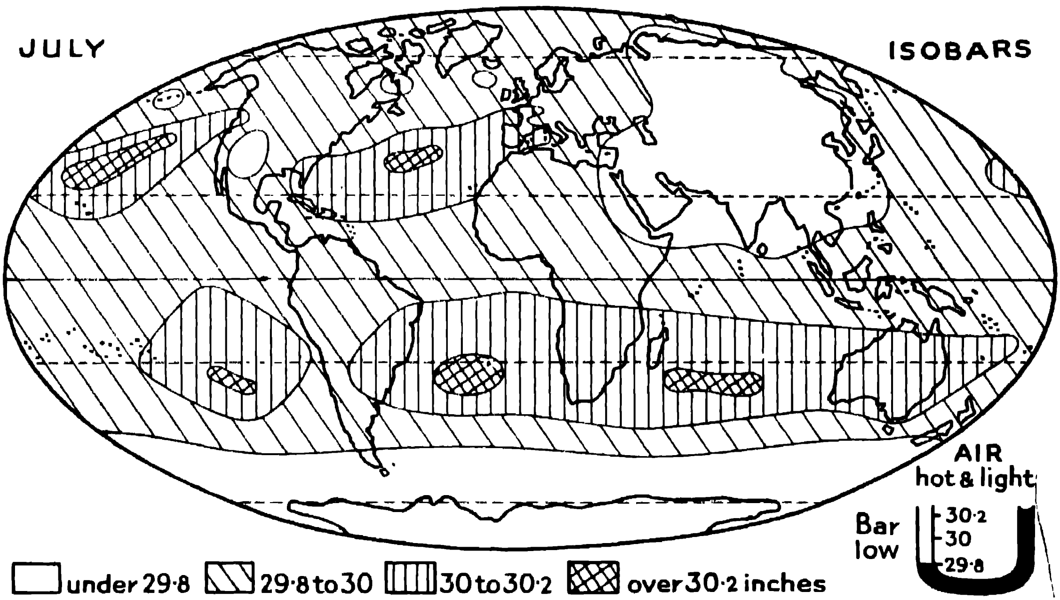


Fig. 21a. AVERAGE ATMOSPHERIC PRESSURE over the earth's surface during July.

example, over the Pacific Ocean there is no area with an average temperature of over 80 F., either north or south of the equator. Even mere nearness to the sea affects temperature in this way, as is illustrated by the cooler strips running south along the west coasts of South America and South Africa during the southern summer, and running north along the west coasts of North Africa and North America during the northern summer.

Continental Isotherms

North Africa, during its summer, provides a striking illustration of the conditions described. This land mass appears on the map as the most extensive area with this very high average temperature ; off its west coast the isotherms are so close together as almost to make the region of cooler air continuous from north to south over the Atlantic.

When the areas with low temperature are considered, the same thing is noted. During the northern winter nearly half North America and more than half the immense area of Asia have an average temperature of below 32° F. (freezing point). Between the two, under the moderating influence of the Atlantic Ocean, the isotherm of 32° F. is bent so far north that all north-western Europe, nearly to the Arctic Circle, is included in the warmer area, with a mean temperature, for January, of over 32° F. Note also how the isotherm of 32° F. turns sharply north along the coast of eastern Asia.

A comparison of the facts stated here provides an illustration of what is meant by continental climate and oceanic climate respectively. Continental climate is characterised by extremes (hot summers, cold winters), because air over a land surface becomes hot or cold quickly. Oceanic climate is more moderate, because air over the sea is warmed or cooled more slowly.

Isobars

The distribution of atmospheric pressure is shown on a map by means of isobars, i.e. lines joining places of equal atmospheric pressure. As in temperature maps, isobars are more or less numerous according to the scale of the map.

The two maps or charts Figs. 21 and 21a show the average atmospheric pressure over the earth's surface (land and sea) for the months of January and July. Here again a correction has been applied to reduce the pressure readings to sea level. Thus the isobaric charts only show actual conditions correctly over the oceans—a point to be remembered when using them. Hot air is light and tends to rise ; cold air is heavy and presses downwards. As temperature is observed by means of the thermometer, so atmospheric pressure is recorded by the barometer, i.e. measurer of weight (of air). The small inset diagrams illustrate the effect of light and heavy air on the barometer, and serve to explain the meaning of the reference to inches appearing under the maps.

LESSON 6

Winds, Tides, and Ocean Currents

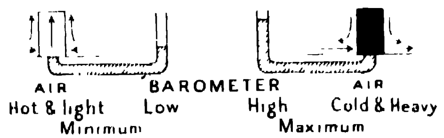
THE weight of the air and its pressure on the earth's surface vary within narrow limits. This pressure, as was explained in Lesson 5, is measured by the barometer, and under average conditions may be taken as equal to the pressure of a column of mercury just under 30 inches high.

Air over a surface heated by the sun is warmed quickly over the land, more slowly over the sea. When air is warmed, it expands and rises, as does the air in a chimney when the fire is lighted. If it rises, it must be lighter than it was before. Hence it exerts less pressure, and as it cannot support as large a column of mercury as it formerly did, the barometer falls. As hot air is light, so cold air is heavy and tends to sink. It can support more mercury than it could before, and the barometer will rise.

These are the phenomena which the two charts of atmospheric pressure, Figs. 20 and 21a, show for the whole surface of the globe, in the shape of the averages for the months of January and July. Comparing the charts referring to the same month, the student will see how changes of temperature affect atmospheric pressure.

Atmospheric Pressure

In January (northern winter) the cold areas of North America and Asia are represented by two areas of heavy pressure, with areas of lighter pressure between them, because air over the sea keeps warm longer. In July (northern summer) the areas of light pressure are over the land, because air over the land becomes hot, and so light, more quickly than over the sea.



BAROMETER. Fig. 22. Showing the principles upon which a barometer works.

In the southern hemisphere January (southern summer) shows very clearly how the heating of South America, South Africa, and northern Australia makes for light pressure over those regions, while the Pacific, Atlantic, and Indian Oceans have corresponding areas of heavier pressure. Conditions are not quite so clearly marked in the southern hemisphere during July (southern winter), as the land areas are comparatively small and have not so strong an influence as the vast land mass of Asia.

Fig. 22, showing how a barometer works, indicates the connexion between atmospheric pressure and the direction of the wind. If the air rises over a certain area, winds will blow inwards towards the centre of that area, to take the place of the air which has risen. When the air over an area sinks, winds will blow outwards.

If temperature and, consequently, pressure were influenced by latitude only, there would be winds blowing constantly from north and south towards the latitude at which the sun, being overhead at noon, warms the earth's surface most quickly and thoroughly. The irregular distribution of land and sea affects the distribution of temperature, and consequently of pressure also. It thus influences the direction of the prevailing winds, shown, again for January and July, in Fig. 23.

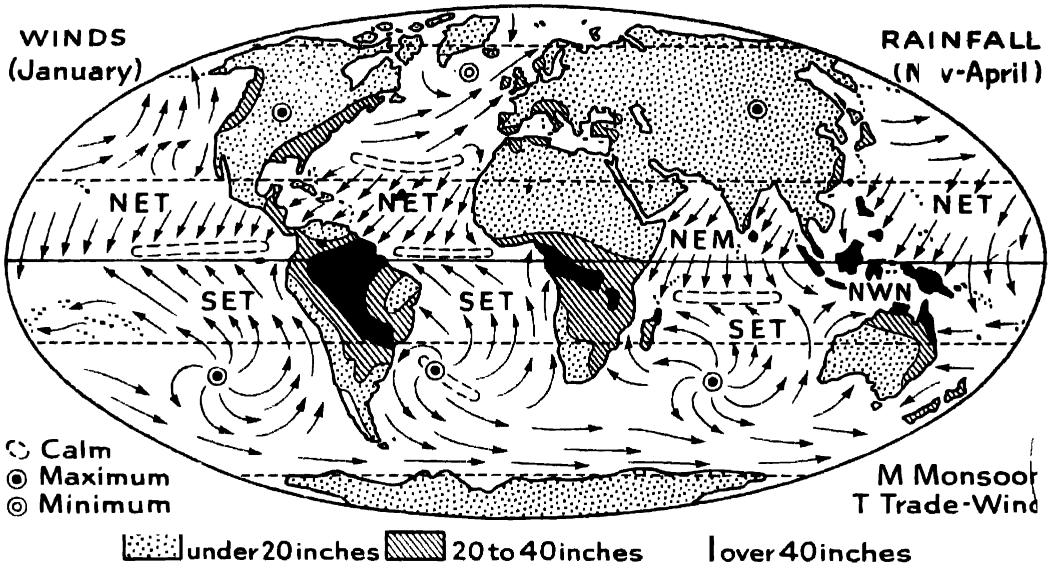
Chief Centres of High Pressure

For the sake of clarity, the chief centres of high pressure (maxima) and of low pressure (minima), from or to which the chief wind currents are directed, have been marked on these two maps. Winds do not, however, blow directly outwards or inwards from or to these points. The earth's rotation causes them to be deflected to the right in the northern hemisphere, to the left in the southern. A north wind blowing towards the equator becomes a north-east wind, a south wind blowing towards the equator becomes a south-east wind.

Origin of Winds

The foregoing explanation should enable the student to trace the origin of the winds shown in the diagrams as blowing regularly from the north-east in the Pacific and Atlantic Oceans north of the equator, and from the south-east in all three oceans in the southern hemisphere. These are the "trade" winds, so called because in the days of sailing ships they were of paramount importance to traders on the great ocean routes. Over the vast expanse of the southern ocean which surrounds the Antarctic continent, the south-east trade winds become merged in the prevailing westerly winds, called, from their average latitude, the Roaring Forties.

In the northern Indian Ocean conditions are different, owing to the influence of the great land mass of inner Asia, which is very cold in winter and very hot in summer. In January winds come from the north-east, driven by the high pressure prevailing over a cold area, but in July they blow inwards to the region of hot, light air. These are the north-east and south-west monsoons respectively, features of the climate of the Indian sub-continent. Similar



phenomena occur in the western Pacific and along the west coast of Central America.

The direction of the prevailing winds affects the distribution of the world's rainfall, which the maps show, not for two single months but for half the year in each case. A wind blowing inland over the sea (*see* Fig. 24), especially if that sea is warm, carries moisture, which it will deposit as rain when it strikes high ground. If it has passed over dry land, it will be a dry wind and bring no rain.

The contrast is most marked in the Indian sub-continent. The north-east monsoon, coming from the cold, dry region of central Asia, carries no moisture. The time when it is blowing is the country's dry season. The south-west monsoon has been blowing over the warm Indian Ocean and brings to the Western Ghats and to the southern slopes of the Himalayas in particular, as well as to south-eastern Asia generally, some of the heaviest rainfall to occur on the earth's surface.

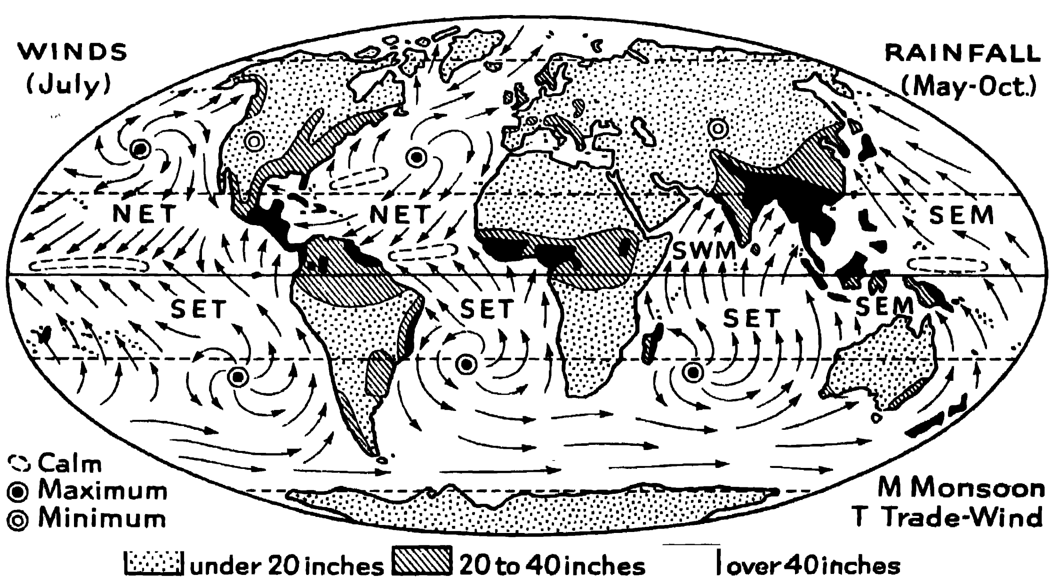
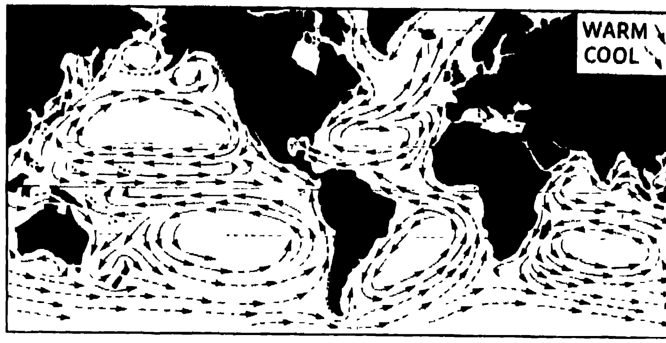


Fig. 23. WINDS AND RAINFALL. Direction of the prevailing winds during January (top chart) and during July (lower chart).

The student should be able to find for himself other examples, as shown in the maps, notably the regions covered by the two great equatorial rain forests of South America and central Africa. The movement north and south of the areas of heaviest rainfall is due to the fact that the hottest area is north or south of the equator, to correspond with the northern and southern summers.



SURFACE OCEAN CURRENTS. Fig. 25. A phenomenon of great importance to climate is shown here in simplified form. The currents are regular if the wind is continuous. Most of the surface ocean currents flow steadily all the year in the same direction—the direction of the prevailing winds.

High and Low Tides

The ocean is in constant motion, in a number of ways. First there is the movement of the tides. These are closely associated with the phases of the moon. They are due principally to the attraction of the earth's waters by the mass of the moon, which has the effect of heaping up the waters of the ocean at the point on the earth's surface on the line connecting the centre of the earth with the centre of the moon. The point is constantly changing owing to the rotation of the earth on its axis, and if the earth were covered entirely by a film of water, the tide would sweep steadily round and round the world in harmony with this rotation. But the intervention of land masses stops and deflects the onward rush of the waters, and partly accounts for the differences in high and low tide at different places on what would be the line of the tide's sweep if it were uninterrupted.

Spring Tides

Another factor causing tidal variations is the attraction of the sun's mass for the earth's waters, which is similar to that of the moon, but, being farther away, is less powerful. When the point of the sun's attraction differs from that of the moon, it has a counteracting effect, and there occur tides of reduced volume, called neap tides; when the two points approximate to one another, as they do at the time of full and new moon, their effect produces the specially high tides called spring tides.

Surface Ocean Currents

A phenomenon of great importance to climate, and, in the days of sailing ships, to mariners, is illustrated in Fig. 25, namely, surface ocean currents. These are caused by the wind, which, acting on the surface of the sea, not only causes ripples and waves but also, if continuous, sets up regular currents, shown in the diagram in simplified form.

Most of the surface ocean currents flow steadily all the year in the same direction—the direction of the prevailing winds. The warm Gulf Stream (or North Atlantic Drift), to which Great Britain and north-western Europe owe indirectly their much milder climate than that of other countries situated in similar latitudes, flows steadily from the Gulf of Mexico in a north-easterly direction across the Atlantic. The Labrador current, which is partly responsible for the long, bitter winters of eastern Canada, flows steadily southward between Greenland and the east coast of North America. In the northern Indian Ocean can be seen particularly clearly the effect of the prevailing winds in setting up surface currents, for the north-west

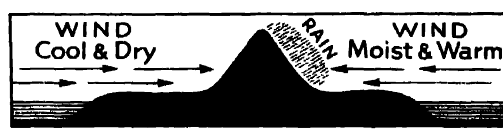


Fig. 24. Diagram showing why some winds bring rain and others bring dry weather.

and north-east monsoon drift of January changes, with the changing wind, to the south-west and south-east monsoon drift of July.

But these surface currents affect the ocean to a very small depth only. Below the surface are other currents, and about these and their causes much remains to be discovered. The relative salinity and density of the water, and its varying warmth in different areas, certainly help to determine the direction of these deep water currents. Saltier, heavier water tends to flow beneath lighter, less salt water—one result of which is that the very salt waters of the Gulf Stream, after they have been cooled as they move past Norway, are found at the bottom of the sea below the less salt waters of the Arctic Ocean. In general, the deep sea currents are cold currents flowing from the waters of the Arctic and Antarctic towards the equator.

LESSON 7

How Landscape Features Originated

This Lesson is devoted to a consideration of the more important of those surface features of the land, such as mountains, rivers, lakes, and glaciers, which not only form the landscape but play such an important part in influencing the distribution and mode of life of the human race.

The stratified rocks, which cover so much of the earth's surface, were originally deposited horizontally (Fig. 26), in the form of mud, the product of erosion, carried into lakes and the sea by rivers, and sinking to the bottom in the still water. In the Grand Cañon of the Colorado river the strata are seen in their original horizontal position, easily distinguishable by their various colourings.

Evidence of the changes of level by which such tracts have now become dry land is of various kinds. Fossil remains of sea or lake animals and vegetation are found at quite considerable heights above present-day sea or lake level. Such a formation as the Roads of Glenroy, near Ben Nevis, probably marks three successive positions of the shore of a lake.

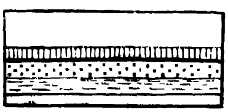


Fig. 26. Horizontal strata

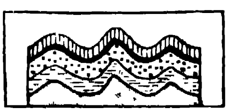


Fig. 27. Folded strata

Fig. 28. Fan-like folding

These changes of level can be only very slow and gradual, and would not have produced the much diversified landscape which the earth has to-day. There would have been no mountains. These features are due to movements of a more violent nature and are classified in to four types: folded mountains, block mountains, highlands of erosion, and volcanoes.

Mountain Formations

A characteristic example of folded formation is that of the Jura mountains, along the Franco-Swiss frontier. The horizontal strata of which they consist now cover a much smaller area than formerly, with the result that they have been thrown into the shape of waves or folds by pressure in a horizontal direction. From time to time the earth's crust has been thus affected, and more or less regular ridges have been formed (Fig. 27). If the force and extent of compression are very great, there may be an almost fanlike shape (Fig. 28), an example of which is on the shores of Lake Titicaca in South America. Most of the earth's greatest mountain systems - the Himalayas, Alps, Carpathians, and American Rockies —were formed in this way, although other agencies, especially erosion by running water or ice, have been at work to shape their details and give them their present outline.

Isolated Blocks

The term block mountains is usually applied to a range which has been raised above the general level, or left standing as isolated blocks by the sinking of the surrounding country. A striking example is the Harz mountains, which not only overlook the great plain of northern Germany but are flanked by low-lying districts of smaller extent The earth movements which bring about such formations often work violently

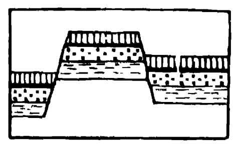


Fig. 29. Block Mountain

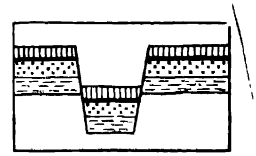


Fig. 30. Rift Valley

in a vertical direction, and are called "faults." A mass of sedimentary rock, deprived of its foundations by the collapse of some great subterranean hollow, sinks down, leaving one or more blocks of strata in their original position as shown in Fig. 29.

The great rift valley of East Africa has a similar origin. Another example is the Rhine valley between Basle and Mainz (Fig. 30). The geological formation of the highlands (the Vosges and Black Forest) for nearly 200 miles shows that the strata were once continuous, though now separated by a valley nearly 20 miles wide.

Folded mountains may be worn down into rugged peaks and ridges by the action of running water or ice. This action, when applied to undisturbed sedimentary rocks, will not perhaps produce such fantastic shapes as that of the Matterhorn, but in some parts of the globe the details of the surface features are due entirely to a former glacial covering. The English Lake District has been carved out of a block of sedimentary rock by the action of running water and ice, which removed the softer materials, so that the shape of the mountains is only partly due to their original structure. Norway is another region where the fiords—and the narrow valleys continuing them inland—owe their existence and shape to erosion. An example of an isolated block is Table Mountain, Cape of Good Hope, 3,582 feet high.

A bucket of water emptied on the side of a hill will take the shortest way it can find to the bottom. If the soil is soft, it will absorb all or part of the water. If it consists of hard rocks, the water will run over them, still taking the shortest possible way. The inequalities on any hill will not only give to the water a course winding from side to side to avoid obstacles but may also change its gradient, as the slope varies.

The water from the bucket will exhibit on a small scale the phenomena observable in a mountain brook. It will run smoothly over ground of a regular slope ; it will form bends to avoid stones lying in its path ; a steep ledge will produce a waterfall ; should it find its way into a hollow capable of holding water, it will form a pool, in the same way as a river forms a lake. The river will not only take the shortest and easiest way it can find, but will be continually at work trying to make that way shorter and easier still. It does this by erosion and deposition.

Mechanics of Erosion

Erosion signifies the wearing away of the banks of a river (lateral erosion), or the deepening of its bed (vertical erosion). Erosion is mainly mechanical, but if the nature of the rocks is suitable to such a process, they may actually be chemically dissolved, as happens with such materials as limestone and salt Whether mechanical or chemical in form, whether working laterally or vertically, erosion tends to lower the stream's course, to make it easier and more direct ; and just as rough fragments are worn down by the sea waves to the rounded pebbles of shingle beaches, so fragments of rock, large and small, rolled along by a stream not only become smooth and round in their passage but also help to wear away and smooth the ground over which the stream takes its course.

The amount of material which a river can carry along with it depends on the volume of water and on the speed of its flow. The carrying power increases as the sixth power of the velocity : if the rate of flow is doubled, the carrying power will be multiplied by 64, so that a stream able to carry a pebble weighing an ounce will, if its speed be doubled, be able to shift a stone weighing four pounds. When a mountain stream reaches level country, it begins to drop the debris brought from the upper reaches, because of the reduction in speed of its flow.

Gradient of a River Bed

While the wearing away of the banks tends to straighten a river's course, the wearing down of the bed, also effected with the help of debris carried along, will gradually even out the channel and give it a uniform slope. The extent to which a river will be able to perform this grading must depend largely on the varying hardness of the rocks over which it passes. It is not to be expected that any river will have a perfectly uniform gradient from source to mouth. Particularly hard rocks may resist erosive action so successfully as to remain in the shape of small rocky islands or reefs in the river bed. An example of this is the Iron Gates through which the Danube passes from the plain of Hungary to the lowland region of its lower course. A river which approaches a uniform gradient is said to be "well graded."

Deposition of Sediment

If a river had a perfectly straight course, deposition of its debris would take place with perfect regularity throughout ; the larger fragments would be dropped first, then the smaller ones, while the sand and mud would be carried down to the mouth and even out to sea. A river with a winding course will have its swiftest current not always in the middle (as would happen with a straight course), but on one side. The current being swifter on the outside of a bend, that part of a river will be able to carry the sediment away, thus keeping its bed clear and its channel deep. On the inside of the bend, in the more sluggish water, deposits of sediment collect.

When a river overflows its banks and floods the surrounding country, the sediment which it has brought down from its upper reaches will be dropped by the comparatively sluggish water of the flooded area outside the regular course. It is in this way that the Nile every year spreads over the surface of the land the silt brought down from East Africa. When a river finally reaches a lowland plain, it will be flowing too slowly to carry any but quite small particles of erosive products. The dredging operations necessary in the lower reaches of such rivers as the Rhine, Elbe, Rhône, and others, are evidence of this. The most striking result of the carriage of sediment to the mouth of a river is seen in the formation of deltas like those of the Ganges and the Nile.

Lake Formation

Heavy rainfall or the sudden melting of snow in an upland area may so increase the volume of water in a river that in its course through level country it overflows its banks. When the water has had time to drain away, the river will return to its normal size and course. Under certain conditions this overflow might have been prevented from draining away. The temporary flooding would then have become permanent, taking the form of a lake. The large and small lakes dotted over the earth's

surface owe their existence to a variety of causes. Three geological phenomena have brought into existence hollows capable of holding water. These are erosion, deposition, and movements of the earth's crust ; lakes owing their origin exclusively to one of the three are somewhat rare.

A lake formed by erosion can generally be recognized by the fact that it is completely surrounded by rather hard rock. When a river pasess over a bed of soft rock, this will be eroded more quickly, forming a hollow which must be filled before the river can proceed on its course. Glaciers, too, gouge out hollows which may eventually form lakes.

Dams and Lagoons

Erosion by a river may take the form of actual chemical solution, and this occurs not only at the surface but also by means of underground streams, which easily dissolve such material as limestone and salt. Underground hollows are formed, which ultimately collapse and, when filled with water, become lakes. Often it is only the deeper portion of a lake basin which has been formed in this way.

Deposition most frequently takes the form of a dam of sediment built across a valley or at its mouth, which may either form a new lake or increase the extent and depth of an already existing rock-basin. In addition to the sediment carried by the streams, there is the debris brought down, in the form of moraines, by a glacier and deposited at its foot. Most of the Alpine lakes have been formed by the accumulation of glacier debris.

Lakes formed by deposition in lowland areas frequently take the form of lagoons, cut off from the sea by river deposits, or by the products of sea erosion, transported by current and tide. Of this character are the lagoons of the Adriatic coast between Ravenna and Trieste. The Norfolk Broads, though now mostly at some distance from the sea, were formed in this way, and some of them are still within reach of the tide.

Deposition may take the more violent form of a landslide extending right across a valley and so building up a dam. A view of the eastern side of Wastwater, in Cumberland, shows clearly how the screes of Scafell, which may be described as a permanent landslide, have altered the original shape of the lake.

Lakes in the volcanic areas frequently take the form of crater-lakes. Lake Avernus, near Naples, was created in this way.

The animal kingdom also plays a part in this work. The lagoon of a coral island owes its existence to the reefs built up by the coral polyp. Another lake-forming animal is the beaver, with its dam-building habits.

Changes of Level

Rift valleys are formed by the sinking of blocks of sedimentary rock. In the lower portions of such valleys water will naturally accumulate to form lakes. The best-known example is the Jordan valley, the lowest portion of which is filled by the Dead Sea. Lake Baikal in Siberia is another instance of a lake formed by a geological fault, as are also Lakes Nyasa and Tanganyika, in Africa.

Very often the strata have been tilted to form the furrow in which the waters of the lake have collected, as in the case of Lake Titicaca in South America. The great lakes of North America were probably formed (at least partly) in this way, though here, in old shore-lines (once horizontal, but now tilted), is found evidence of earth movements since the lakes originally formed.

Changes of level over large areas may also lead to the formation of lakes. The Caspian Sea and the Sea of Aral, now inland drainage areas, were once part of the sea, since cut off by a rising of the land. The whole of the shores of the Caspian, as well as part of the bottom of the Aral Sea, lie below the general ocean level.

LESSON 8

Volcanoes of To-day and Yesterday

A COMMON theory as to the immediate cause of volcanic action is that cracks in the earth's crust admit the sea to the earth's intensely hot interior, explosion being brought about by the sudden formation of vast quantities of steam. This theory leaves two things unexplained. First, there are some volcanoes at a considerable distance from the sea, such as Mt. Teleki and Mt. Kirungo, near Lake Rudolf in East Africa, and Koh-i-Tafdan in eastern Persia. Secondly, there are considerable stretches of coast without volcanoes.

This theory is therefore now authoritatively regarded as erroneous, and the immediate cause of a volcanic outburst is sought rather in such occurrences as the development of gas or steam, due to the cooling of molten rock, or to the mechanical pressure exercised by the collapse of some great subterranean hollow filled with molten matter. The simplest way of defining a volcano is to describe it as a hole in the earth's surface through which molten matter is thrown up. But there is considerable variety in the phenomena which accompany the eruption.

Volcanoes of the type of Mt. Vesuvius seem to follow a regular programme, beginning with warning earthquakes. The liberation of gas and steam is then followed by the throwing up of ashes, accompanied by rain and sometimes thunderstorms, and concluding with a generally quiet and steady outpouring of lava.

Vesuvius was believed to be extinct till A.D. 79, when the eruption in which Pliny the Elder lost his life overwhelmed Herculaneum with mud and Pompeii with ashes. The eruption of 1631 was even more terrible than that of 79, and destroyed two towns with most of their inhabitants. Since then the character of the mountain's activities has changed. Eruptions of Vesuvius have been more frequent, but individually less alarming.

Types of Eruption

Mount Etna, the loftiest of Europe's volcanoes, came into existence as an island volcano close to the east coast of Sicily. By filling up the narrow strait with the debris of successive eruptions, it ultimately joined itself to the main island. Of 80 recorded eruptions, that of 1669 was the worst, especially in the matter of the outpouring of lava. Vesuvius has one main crater, with a few subsidiary outlets scattered over its extensive surface. The main crater of Etna has fallen in on one side, forming a gorge with steep sides, the Val di Bove, and eruptions now take place through small scattered craters, of which there are nearly 200. Etna's most recent destructive eruption was in 1928.

The eruptions of Krakatoa (1883), between Java and Sumatra, of Mt. Tarawera (1886), in New Zealand, and of Bandaisan (1888), in Japan, were quite different from those described. They were really explosions—in the true sense of the word—of subterranean accumulations of gas and steam, which at Krakatoa and Bandaisan blew away a large part of the mountains in which they occurred, and then threw up vast quantities of rock fragments and ashes, but there was no lava.

Lava eruptions, pure and simple, are rare. The best-known examples are the Hawaiian volcanoes. A characteristic Hawaiian eruption takes place without anything in the nature of an explosion. An enormous mass of lava, in a very liquid state, rises until it overflows the crater's edge, obliterating everything that lies in its path.

Water-vapour and Sulphurous Gases

A quite different phenomenon was witnessed at the eruption of Mt. Pelée, in the island of Martinique, French West Indies, in 1902. This ended, not with an outflow of lava, but with an avalanche in the shape of a cloud of water-vapour laden with glowing ashes, which rolled down the side of the mountain and destroyed the town of St. Pierre.

A more recent volcano, Paricutin, in central Mexico, appeared as a plume of smoke in a cornfield in February 1943. In 12 months it had reached a height of 1,500 feet.

When a volcano is described as extinct or dormant, it does not follow that volcanic activity has ceased altogether. It may manifest itself in various ways, though not so violently as in an actual eruption. Instances of this kind are the so-called solfataras, from which issue clouds of steam laden with sulphurous gases, as in La Soufrière, in the island of St. Vincent, British West Indies, which erupted in 1902 and devastated nearly half the island. The geysers of the Yellowstone National Park, U.S.A., and of Iceland belong to this class of volcanic activity.

Perhaps the most interesting example of what might be called expiring volcanic action is in the Rotorua district of New Zealand (North Island), where these phenomena may be studied in all their various forms of solfataras, geysers, fumaroles or smoke geysers, hot springs and lakes, and mud volcanoes. The famous pink and white terraces of Lake Rotomohana were destroyed by the eruption of Tarawera in 1886

A form sometimes taken by an extinct volcano is that of a crater-lake. Lake Taupo in New Zealand is an example. Others are in the U.S.A. (such as Lake Mazama in Oregon), in the Auvergne, central France, and in the Eifel district of Germany.

LESSON 9

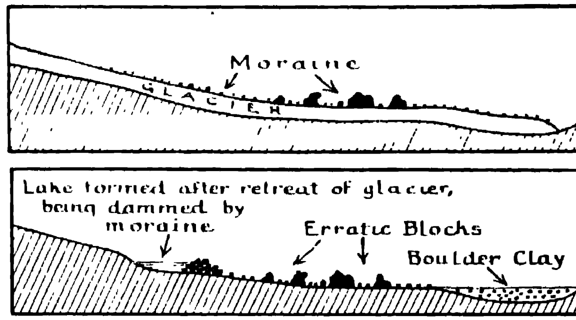
Glaciers, Ice-fields, and Icebergs

A MAP of the earth's ice covering (past and present), unless on a fairly large scale, could not show the distinction between the several Ice Ages of which there is evidence in various parts of the world ; it would probably display merely the extreme limits to which at any time the two present-day ice-caps (Arctic and Antarctic) extended respectively south and north towards the equator, and the extent to which some ice-fields in other parts of the world exceeded their present dimensions.

The general climatic changes which caused these successive advances and retreats of the ice covering were so widespread that not only the Alps, the Caucasus, and the mountains of central Asia, but even Mts. Ruwenzori, Kenya, and Kilima-Njaro in Equatorial Africa, as well as the Southern Andes, all pushed their glaciers

down to levels which to-day they are unable to reach. In South Africa and south-eastern Australia, too, is evidence of former glaciation.

Evidence appears in several forms. For instance, rocks have been scratched (striated) or polished by the passing over them of long-vanished glaciers ; small fragments of rock, as in the so-called boulder clay, have been transported by glaciers, deposited when these retreated, and finally covered up by later sedimentary deposits ; larger fragments, when transported in this way and left stranded, are called erratic blocks (Fig. 31).



GLACIAL ACTION. **Fig. 31. Top, sectional drawing showing a portion of the earth's surface covered by a glacier in the Ice Age. Lower, the same portion to-day, the glacier having long since disappeared.**

Glaciated valleys have the form of a deep, rounded "U" instead of being V-shaped in cross section as in the normal type of river valley. They have long stretches that are "unnaturally" straight, and the tributary valleys, for the most part, enter high up the steep valley sides and from their mouths streams tumble in waterfalls into the main valleys.

Ice-fields and Glaciers

The two great ice-fields of to-day are Greenland (708,000 square miles) and the Antarctic continent (5,700,000 square miles). About 75 per cent. of Greenland's area is covered by an ice-cap in places 6,000 feet thick, formed by pressure of the overlying snow which has turned the lower layers into ice. This pressure has the further effect of setting up in the whole mass a downward and outward movement which manifests itself in enormous glaciers, such as the 60-miles-wide Humboldt Glacier. The largest European ice-field is the Jostedalsbrae, in Norway, from which several glaciers descend to within 200 feet of sea-level—a lower level than is reached by any glacier not actually within one or other of the polar circles.

The névé (snow-field) feeds the glacier, and is drained by it, just as a lake or swamp is drained by a river. When a glacier has to descend more steeply over a ledge of rock, the ice is broken up by crevasses and forms an ice-fall or a sérac (a pointed mass or pinnacle of ice). As it moves down the valley, a glacier will collect on its surface debris that falls from the steep slopes on either side. These fragments form the moraines, called lateral or medial according as they are at the sides or in the middle of the glacier. Further debris is transported by the friction of the glacier along the valley-bottom, the whole being deposited at the foot (snout) of the glacier as an end-moraine from which issues the glacier stream formed by the melting of glacier ice. The rate of movement of glaciers varies considerably. Advance of several hundred feet a year is fast ; often the annual movement is only a few feet. Movement is quickest at the surface and in the middle, being retarded by friction at the sides and bottom.

There are two ways in which Arctic icebergs are formed. A glacier, on reaching the sea, pushes on under water until the end of the glacier, buoyed up by the water, breaks off and rises to the surface as an iceberg. Glaciers reaching a precipitous coast push their ends over the edge until they break off and fall into the sea. As might be expected from the rather violent manner of their formation, the icebergs of the northern Atlantic, most of which come from Greenland, are often fantastic in shape. This is not so marked a feature in those of the southern ocean, because there the icebergs originate differently.

Having a much smaller snowfall than the Arctic, the Antarctic continent has fewer glaciers. But the Great Ice Barrier, by which Captain Cook (1773) and Sir James Ross (1841) found their way south effectually barred, is a formation peculiar to the Antarctic. It is the breaking up of this barrier, or shelf-ice, which originates the southern icebergs, most of which are not as high as those of the north, though often greatly exceeding them in surface area.

Drift-ice

The term drift-ice includes not only icebergs but also the floes into which the Arctic pack-ice and the Antarctic shelf-ice break up on the approach of summer. Its distribution is strongly influenced by the prevailing ocean currents. The effect of the Gulf Stream in preventing the drift-ice from reaching the British Isles is very marked, while the cold Labrador current often carries it as far south along the Atlantic coast of North America as Cape Hatteras, in the latitude of Gibraltar. In the southern ocean the prevailing westerly winds prevent the drift-ice from travelling any great distance north.

Owing to the continual play of the currents, the Arctic Ocean (except in the extreme north) is never completely frozen over, its ice covering

consisting rather of cakes of ice (floes) which become smaller and less numerous as the summer advances.

The distribution of sea-ice in the northern portions of the Atlantic and Pacific is largely influenced by the prevailing westerly winds in those areas, with the result that the western coasts of North America and Europe and Asia are generally warmer than their eastern coasts. Thus the rivers and harbours of northern China, in the latitude of the Mediterranean, are mostly ice-bound in winter, as is also the Gulf of St. Lawrence, which lies in the latitude of the English Channel.

The freezing over of certain seas causes seasonal changes in some of the steamer routes. When Quebec becomes inaccessible by the freezing of the Gulf of St. Lawrence, Halifax, which is ice-free, takes its place as Canada's chief port of entry. The line connecting Port Churchill, on Hudson Bay, with the Saskatchewan railways, for the direct export of the prairie wheat, is useless in winter.

Lakes generally freeze from the surface—much more slowly when exposed to wind. Of the North American lakes, Lake Erie, the most southerly, freezes along the shore only ; the others, usually all over.

Rivers mostly freeze from below (ground-ice which rises to the surface). In western Europe rivers do not always freeze in winter, though they may frequently become blocked for a time by accumulations of ice brought down from their upper reaches.

Snow does not play such an important part in physical geography as ice. For statistical purposes it is usual to reckon a foot of snow as equal to an inch of rain. The length of time during which snow lies on the ground varies with latitude and with elevation above sea-level, till the lower limit of permanent snow, the snow-line, is reached. The height of this line varies from sea-level in most parts of the polar regions to about 16,000 feet in the Himalayas and the tropical parts of South America and Africa. As regards Europe, the snow-line is at nearly 9,000 feet in the Pyrenees, about 7,000 feet in the Alps, 3,000 feet in Norway.

LESSON 10

The Shaping of Shore Lines

A CONTINENT with so simple and uniform a table-land formation as that of Africa would not have a very complicated outline. In western Europe the long, much-indented shore line seems to be the natural result of a varied land-surface formation. The nature of the land along the coast will be responsible for the main features only. For the working out of the details, one must look to two other factors : movements of the earth's crust and the action of the sea.

The effect on the shape of a shore line of the rising or sinking of the land is illustrated by the sketch-map of a port on a rocky coast (*see* Fig. 32). At high tide—which is the same as saying that the land has sunk—there will be quite a complicated outline of coast, with deep indentations. At low tide, when the land has risen, a level stretch of sand will be exposed, and the outline will be much simpler.

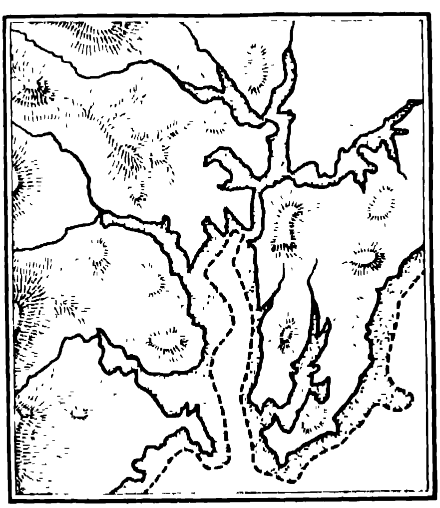


Fig. 32. Sketch-map of a coastal port showing the shore lines at high tide and at low tide.

Bays formed by the sinking of land can be described as "drowned valleys." Their shape will vary with the nature of the land along the coast. Sydney harbour, Australia, reproduces in its outline the shape of a valley which descends from the east-coast range at right angles to the coast. Another type of drowned valley is San Francisco harbour. Its entrance, called the Golden Gate, represents a transverse valley through which the sea has gained admittance, to form, in the low-lying region behind the coast range, the actual bay. Where there are two or more parallel coast-ranges, with transverse valleys, there are such coasts as those of Dalmatia, southern Chile, and British Columbia, where the sea has got in behind the outer range. This latter is now represented by strings of rocky islets, the drowned valley by a narrow strait separating them from the real coast-line, now formed by what was the inner range.

A form of drowned valley occurs where

glaciers have been at work. Here the result will be a long, narrow, steep-sided bay, called a fiord. It is generally shallow at its mouth, which is taken as evidence of its glacial origin. The most remarkable fiords are in Norway. Other interesting examples are the sea-lochs of western Scotland, and the narrow inlets of Labrador, Greenland, and the South Island of New Zealand.

Although not producing such striking coastal formations as those referred to, similar processes occur on low-lying coasts. The lagoons (limans) of the Russian Black Sea coast, although the rivers are gradually filling them with alluvial deposit, corresponded strictly, in their original shape, with the contours of the land. The estuaries of the rivers Orwell and Stour, in Suffolk, are also good examples.

Destroying and Building Up

Where parallel mountain ranges run at right angles to the coast, they are reproduced in the shape of long, narrow peninsulas, with narrow bays between them, as in Dingle Bay, Valentia Harbour, and elsewhere in south-western Ireland. This " ria " formation, as it is called, takes its name from the similar type in north-western Spain, where Vigo Bay and Corunna harbour are examples.

The sinking of a low-lying sandy shore lined with sand dunes will result in the formation of coastal lagoons, as in the Landes of south-western France. The Bulgarian salt lagoons were probably formed in this way.

Where the land has risen, the sea floor will be exposed. If level, it will form a coastal plain with a very simple shore line. The southern shore of Hudson Bay is an example of this, as is also the Atlantic shore, south of New York.

The action of the sea on the land along the shore line is of a twofold nature ; destroying and building up. Coast erosion may take the form of a steep cliff-face being undermined by the sea, with the fallen fragments along its base, and sandy beach above low-water mark. Examples of this are at several places along the south coast of England, with its soft chalk cliffs. One of the most striking instances of erosion by the sea is Heligoland, which in A.D. 800 had a coastline of 120 miles, reduced by 1900 to only 3 miles.

Ages in a Shore-line's Life

Low-lying coasts are often exposed to destructive sea erosion of a rather different nature. Storms which on a rocky coast merely increase the eroding action of waves, become absolutely catastrophic when striking low-lying, and therefore defenceless, coasts or islands, e.g. the east coast of England and the coast of the Netherlands in 1953.

Destroying at one place, the sea may be building up elsewhere, and in this latter work the play of the prevailing currents, or of the tide, takes a considerable part. Examples in England are Chesil Beach, Dorset, which now joins the Isle of Portland to the mainland, and the silting-up of the Cinque Ports of Romney, Rye, Winchelsea, and Hythe.

It is permissible to speak of several ages in the life of a shore line. In its childhood a coast presents itself as formed under conditions due to the shape and undulations of the adjoining land. In youth and middle age it has a varied and often broken outline, due to unequal erosion of rocks of varying hardness. In old age the promontories have been worn away to a certain extent, while sand, brought from elsewhere by current and tide, has formed banks and spits across the mouths of inlets and estuaries, which are also being filled up slowly but surely by debris and mud brought down by rivers and streams.

LESSON 11

Stages in Map-making

In examining briefly the principles involved in the field work which precedes accurate map-making, the first step is to consider the geometrical figure, the triangle. The shape of a triangle depends entirely upon the sizes of two of the angles. Triangles of the same shape have their sides in the same proportion. For example, if the side adjacent to the two specified angles in one triangle is one foot in length, and the corresponding side in a second triangle of the same shape is two feet long, it naturally follows that the remaining sides of the smaller triangle are each half of the corresponding sides of the larger triangle.

To make a map of your home surroundings, you can proceed to use the above fact. From a pole fixed in the garden you measure the distance to a pole fixed in a neighbour's garden, say, exactly 100 yards from your pole. The line between the poles is the *base line*. From your pole, point a stick along the base line, and swing the stick over a graduated circle placed horizontally until it points at the neighbouring church spire ; you then record from the circle " the angle of swing." Similarly, measure the angle of swing when the stick is pointed to, say, the factory chimney, the school belfry, the roof of the post office, or the telegraph post. From

the second pole, you measure in the same fashion the angles of swing to the same points, and the following record is obtained :

Angle of Swing

	From your pole	*From the second pole*
To church spire	80	80
„ factory chimney	45	110
„ school belfry	130	30
„ post office	80	70

NOTE.—The post office is on the opposite side of the base line from the other buildings.

You can now proceed to make the map. On a scale of 1 in 600, 100 yards is represented by 6 inches. Draw a straight line 6 inches long, plot the angles already specified, and extend the lines until they meet. The result is similar to Fig. 33, which is drawn on a scale of 1 in 7,200 or 1 inch 200 yards, Having drawn the map, you can use it to discover the distance from one of the six points to any of the others. Because it is necessary to draw a triangle for each point sighted from the ends of the base line, the principle here illustrated is called *triangulation*.

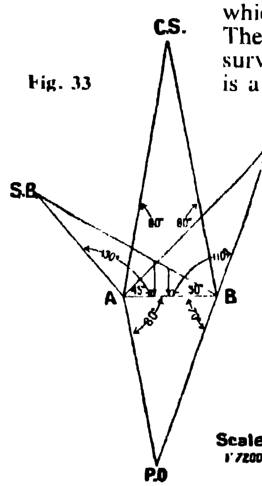


Fig. 33

A.B Base line

Map-making Instruments

The instruments used for triangulation all depend upon the measurement of angles.

A prismatic compass gives the bearings of each line of sight, and from these the angle of swing, or "bearing," is calculated. To facilitate sighting, metal pieces with slits and wires are attached to the compass.

A *theodolite* consists of a telescope for sighting, especially where the distances are great, and two graduated circles, one horizontal and one vertical, on which are read the angles of swing (bearing) and tilt (azimuth) respectively of each object sighted.

It is sometimes desirable to get the triangulation drawn as the sighting is performed. This method obviates the reading of angles in degrees and fractions of a degree, and yields a map drawn out of doors. The instrument for this purpose is a *plane-table*, of which the essential parts are a horizontal drawing-board and a sighting ruler—i.e. a ruler fitted with metal uprights as in the prismatic compass, to ensure absolute accuracy.

In every instance the length of the base line is measured. For this a *surveyor's chain* is usually used. A second principle of surveying is embodied in the method of *off-sets*, illustrated in Fig. 34. This method can be carried out with a chain and a cross-staff, but it can be used only when the surveyor actually goes to the points at the ends of each of the off-sets. Such a necessity limits the usefulness of the method, because it confines it to small areas which are free from obstructions on the ground. The *cross-staff* is an instrument by which the surveyor is able to make sure that each off-set is at right angles to the base line.

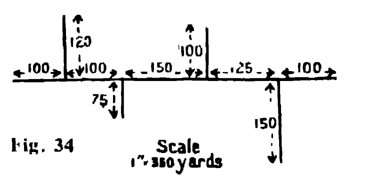


Fig. 34

The way in which these survey methods are used for map-making can be illustrated by the following position.

A commercial air route is under plan across an extent of ocean. An aerodrome with landing and repairing facilities is required about half-way across. An island, Mañana, promises a suitable site, but there are no good maps of it. A party of surveyors is sent to make the desired map as a basis for the purchase or lease of the whole or part of the island.

Specimen Survey

The surveyors approach the island from the north-west, and see the view shown in Fig. 35 They proceed to determine the latitude and longitude of the three Capes, A, B, and C.

A boat party is landed at Cape A, at about 11.30 a.m. The angular elevation of the sun above the horizon at the precise moment when the sun is highest in the sky is measured with a sextant : the value obtained is 62° 15′ 30″. The time, registered by a chronometer which keeps Greenwich time, at the moment of the sun's maximum altitude is 10 p.m. The surveyor proceeds to make the following calculation: The sun's altitude at local noon at Cape A is 62° 15′ 30″—i.e. the sun's distance from the zenith is 90°—62° 15′ 30″ i.e. 27° 44′ 30″. Therefore 27° 44′ 30″ is the difference

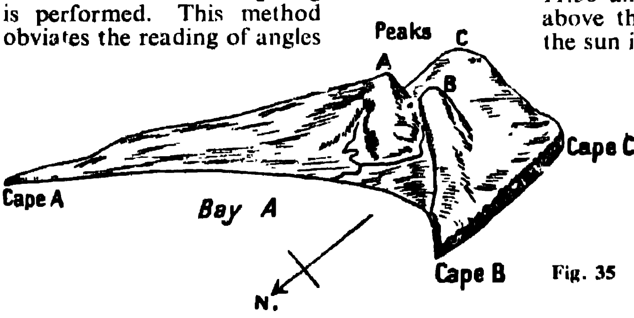


Fig. 35

between the latitude of Cape A and the latitude of places where the sun is exactly overhead on this day.

According to the *Nautical Almanac*, on this day the sun is overhead at lat. 10° 19′ 30″ N. Then the latitude of Cape A is 27° 44′ 30″ + 10° 19′ 30″ N : i.e. 38° 4′ 0″ N. Because the Greenwich time of local noon is 10 p.m., Cape A is $\frac{10}{24}$ of 360° west of Greenwich, i.e. 150° west longitude.

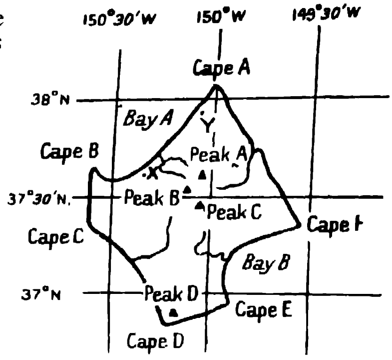


Fig. 36. The first map made in the specimen survey.

By circumnavigating the island and landing boat parties at the several capes, the surveyors are able to make sketches of the coast views and to determine the latitude and longitude of the chief capes. From their observations a *first* map is made, Fig 36, on which the positions of the Capes A to F are accurately fixed, and details of mountain peaks and of rivers are merely sketched in.

Fig. 36 is merely a diagrammatic map made within a square of which the sides represent one degree of longitude or one degree of latitude. One degree of latitude is always the same length, 60 nautical or geographical miles and nearly 70 English or statute miles. One degree of longitude may be merely one statute mile, if it is measured from east to west near the North Pole, or nearly 70 statute miles, if measured along the equator ; consequently Fig. 36 distorts the shape of the island by making it appear broader than it really is. This distortion is not a matter of great importance in a diagram such as this.

Having pitched their camp near the mouth of the stream on the shore of Bay B, on the first clear night the surveyors proceed to check the latitude of Cape F by measurement of the altitude above the horizon of the Pole Star (the latitude of a place is always equal to the altitude of the Pole Star above the horizon measured at that place), which is found to be 37° 21′ 0″. Meanwhile a wireless installation at the camp puts them in touch with the world, and the longitude is checked by exchanging data with the nearest observatory.

The surveyors search for the largest possible stretch of level ground. They decide on the line X Y along the shores of Bay A, and proceed to measure the length of X Y as accurately as possible ; it is found to be 40 miles. The line X Y is the base line for the primary triangulation of the island which is next determined by the following methods.

For the first triangle, theodolites are erected at X and Y, and the angles to Cape B from these places are determined (Fig. 37). Angle *a* is 120° and *b* is 30°. From the known length of X Y and the angles 120° and 30° the distances, of Cape B from X and Y are calculated.

For the second triangle, the angles from X and Y to Peak A are measured ; first the angles of swing, *c* and *d*, and then the angles of tilt above the horizontal, *e* and *f*. The air triangle, X Y Peak A, will appear on a map as

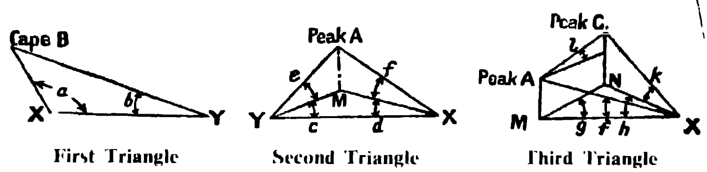


Fig. 37. Methods of measurement used in surveying the island sketched in Fig. 35. The whole island is covered by a network of primary triangles, the angles from point to point being determined and measured with the aid of a theodolite.

the triangle X Y M, and from the known length of X Y and the angles of swing, *c* and *d*, the lengths of M Y and M X are calculated. Using the length M X, and the angle of tilt *f*, the height of Peak A is calculated. By using the length M Y and the angle of tilt *e*, the height of Peak A is determined again, and this last calculation serves to check the whole work.

Up to the present the horizontal base line is used to determine the horizontal first triangles X Y Cape B and X Y Cape A ; and also to determine the positions and heights of Peaks A and B, both of which are visible from X and from Y. But Peak C is not visible from Y, so the line M X and the angle of tilt *f*, which have already been determined, are used in the third triangle.

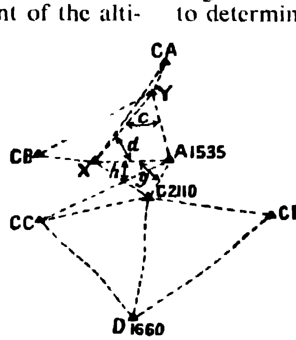


Fig. 38. Parts of the primary triangulation, shown diagrammatically.

The Third Triangle

It is usual to mark the precise points sighted with the theodolite by flagstaffs, or cairns, so that the theodolite is transferred from Y to the cairn on Peak A, and the angle of swing *g* and that of tilt *l* are measured, while the angles of swing and tilt, *h* and *k*

respectively, are measured from X. From these observations the lengths of M N and N X and the height of Peak C are calculated. By using the line from Peak A to Peak C a third triangle is used to fix the position of a cairn erected on the top of the cliff at Cape C, and from this cairn and Peak C the exact position and height of Peak D are fixed.

In this fashion the whole of the island is covered by a network of primary triangles, of which the first few triangles are shown diagrammatically in Fig. 38. This method of map-making depends upon the principle of *triangulation*.

Accurately Fixed

The surveyors have now reached a stage when they know the island fairly well, and they decide that there are two possible sites for the aerodrome, one near the shore west of Cape F, the other on a plateau north-east of Peak D. So the whole area of the triangle C D Cape F (Fig. 38) is more accurately surveyed by a series of smaller secondary triangles, with the result that (i) the coastline of Bay B, (ii) the course of the river which enters the bay, (iii) the situation of the ridges which radiate from Peak C, (iv) the steep edge of the southern plateau, (v) possible railway routes from a settlement near the mouth of the river to each of the aerodrome sites, are all accurately fixed upon a map, as in Fig. 40.

Completing the Survey

Three other pieces of work remain to be done : (a) the survey of the course of the main rivers in connexion with the possible water supply for the town settlement and the aerodrome, and determination of the best

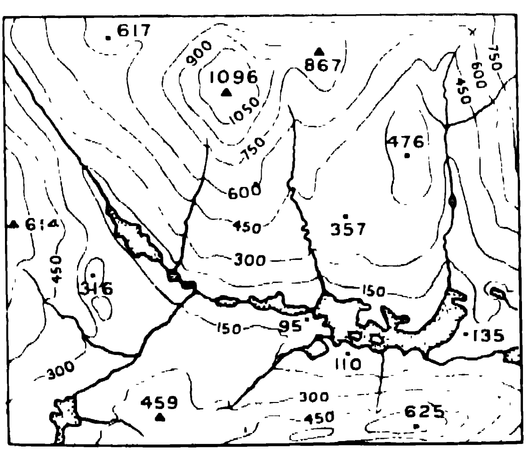
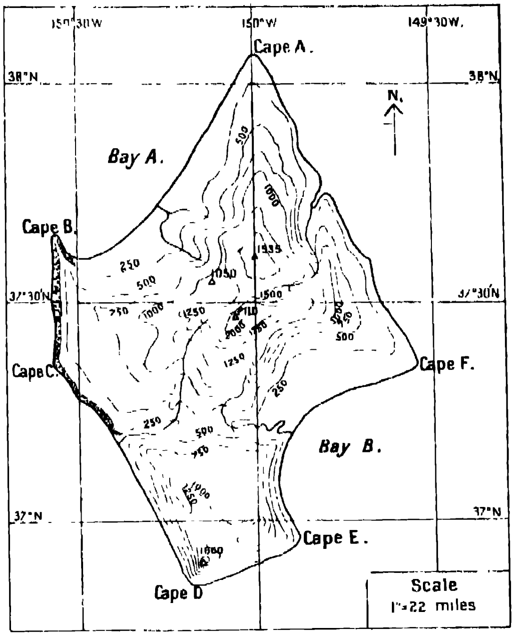


Fig. 39. Diagram showing how contours are drawn by interpolation from spot-heights.



CONTOURED MAP. **Fig. 40. Final result of the survey of the island shown in Fig. 35. By this survey suitable sites were determined for aerodromes and settlements.**

sites for farm settlements ; (b) a still more detailed survey of the immediate neighbourhood of the aerodrome sites ; and (c) a fairly elaborate and detailed survey of the site for the proposed town settlement and for harbour works.

A rapid survey of the main river valleys is carried through with (i) an aneroid barometer, (ii) a plane-table, and (iii) a prismatic compass. The surveyor reaches the river, and fixes the location of a prominent landmark on the bank, chosen for its convenience, by taking compass bearings from two or more of the cairns used in the primary triangulation. He proceeds along the river and draws on the plane-table lines of sight to landmarks on the river bank and to the cairns. At each landmark he determines his height above sea-level by means of the aneroid.

Contours

As a result of the plane-table work a series of sketch maps is made on which " spot-heights " are marked, as in Fig. 39. These spot-heights are used to sketch in contours or height-lines.

Such sketchy contours are not sufficiently accurate for use regarding the rival merits of the two possible aerodrome sites, so the surveyors, equipped with chains, surveyors'

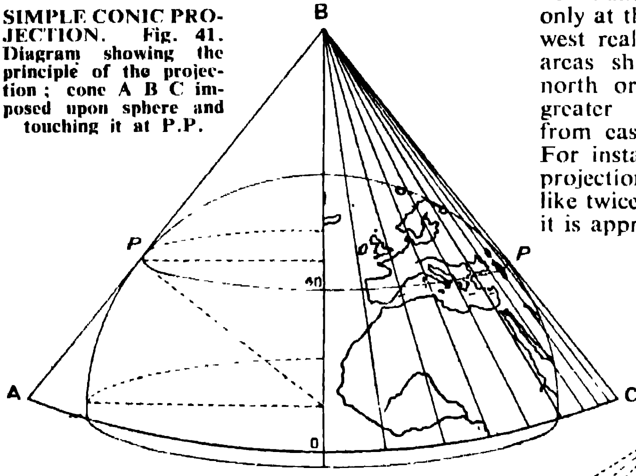
poles, and theodolites, proceed to make detailed surveys of the flat, almost level, areas which they have selected. On these surveys the contours are shown for every 25 feet ; and the sketch contours for these areas are carefully corrected. Then with chain and theodolite a plan of the proposed town settlement is "pegged out," and a map constructed. The final results of the survey comprise a map of Mañana, such as Fig. 40, and large-scale plans of the two aerodrome sites and the town site. Photographs taken from the air are valuable in making a preliminary choice of an area for a particular purpose, and in checking the surveyors' general results, but ground work remains necessary for detailed mapping.

LESSON 12

Methods of Map Projection

As the world is a sphere, it can be accurately depicted only on a globe. But a globe is not very useful for practical purposes such as navigating a ship or planning a campaign, and maps in the flat have had to be devised. Various mathematical methods have been invented for drawing the network of lines of latitude and longitude that forms the basis of all maps ; and maps are made on these different principles according to the size of the area to be represented and the purpose for which the particular map is required.

SIMPLE CONIC PROJECTION. Fig. 41. Diagram showing the principle of the projection ; cone A B C imposed upon sphere and touching it at P.P.



The world as a whole is most commonly represented on Mercator's projection, named after its inventor Gerhard Kremer (1512–1594) (Latinised to Gerardus Mercator), a Flemish mathematician and geographer. In 1569 he made a chart of the world for the use of seamen, in which the meridians of longitude, like the parallels of latitude, were represented as parallel to one another from north to south instead of converging until they meet at the North and South Poles. Fig. 12 and Fig. 25 are drawn on Mercator's projection. Distances north and south of the equator are correct, but only at the equator itself are distances east and west really correct, so that the shapes of the areas shown are distorted, and the farther north or south the country represented, the greater the exaggeration of its "spread" from east to west, and therefore of its size. For instance, in a map drawn on Mercator's projection Canada appears to be something like twice the size of the United States, whereas it is approximately one-fifth larger.

Cylindrical equal-area projection is another way of getting the world mapped in the flat. Suppose a globe representing the earth is

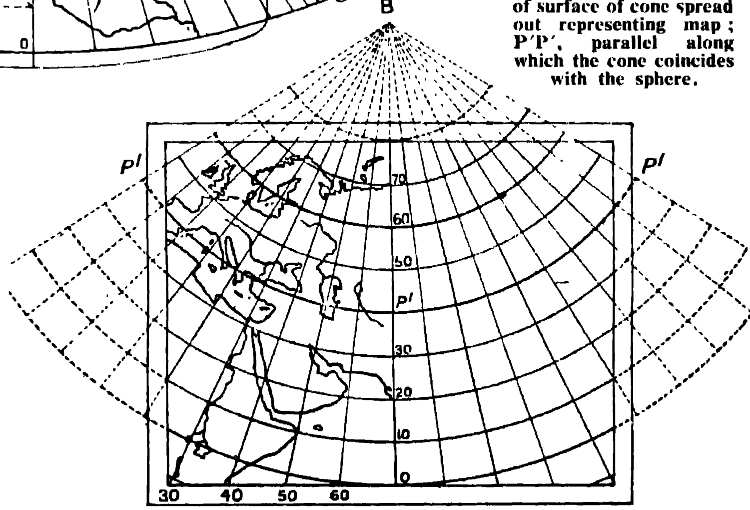
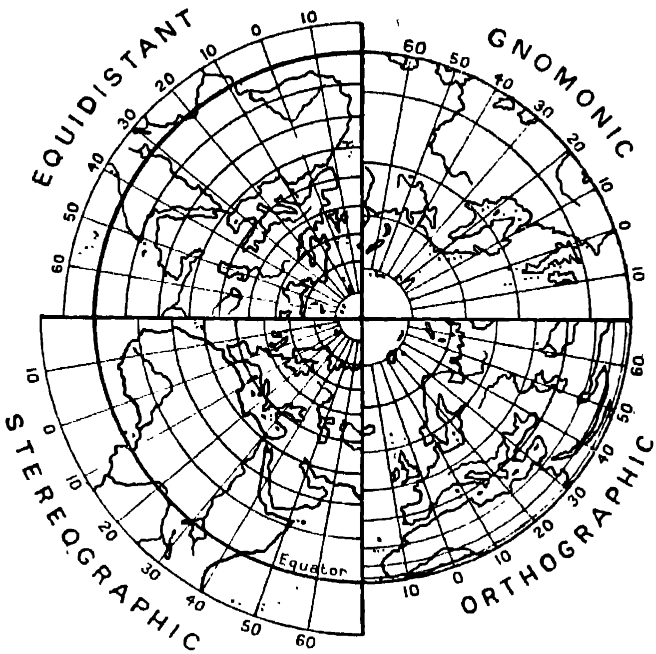


Fig. 41 (cont.). Portion of surface of cone spread out representing map ; P'P', parallel along which the cone coincides with the sphere.

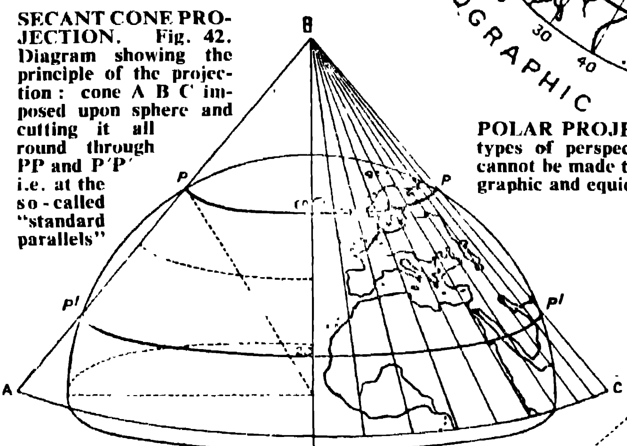
enclosed in a cylinder which touches it at the equator. The planes of the parallels of latitude are projected horizontally to touch the cylinder, which is then unrolled. Meridians of longitude appear to be parallel, as in Mercator's projection, but the distances between the parallels and latitude decrease as one goes north or south of the equator. Distances east and west are correct at the equator, but no other distances are true. The *areas*, however, are correct, and this projection is therefore useful when a map is required to show relative areas.



POLAR PROJECTIONS. Fig. 43. Diagram showing four types of perspective projection. The gnomonic projection cannot be made to include the whole hemisphere. The stereographic and equidistant projections can be extended to include more than the hemisphere.

Conic Projections

The plane of the projection in a simple conic projection (Fig. 41) is the surface of an imaginary cone placed over the earth so that its



SECANT CONE PROJECTION. Fig. 42. Diagram showing the principle of the projection: cone A B C imposed upon sphere and cutting it all round through PP and P'P' i.e. at the so-called "standard parallels"

point is above the pole in line with the projected radius of the earth through the pole, and it touches the earth all round at a given parallel (the "standard parallel"). Distances along this parallel are correct, but there is distortion in the east-west direction north and south of it. The secant conic projection (Fig. 42) increases exactness by imagining the cone as partially sunk in the earth and cutting it along two (standard) parallels, along both of which distances are correct. Bonne's, a modified conic projection, is based on distances measured correctly along each parallel.

A number of projections have been

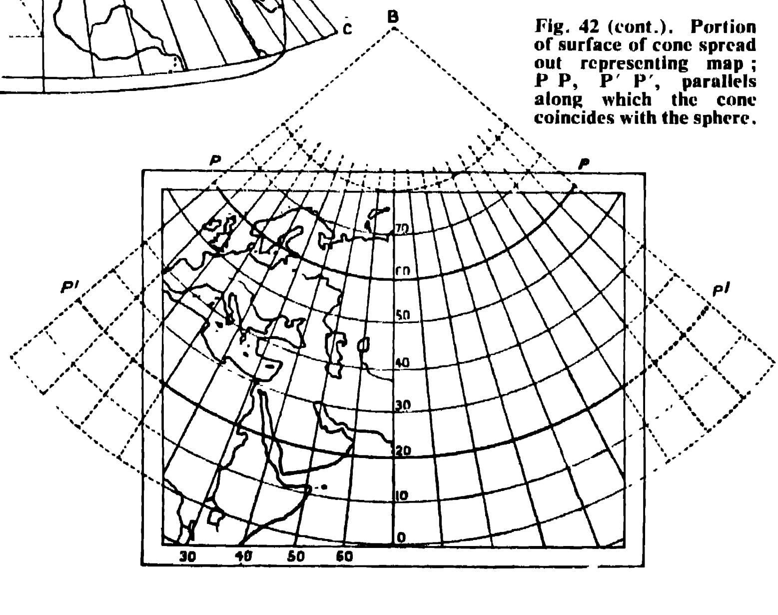


Fig. 42 (cont.). Portion of surface of cone spread out representing map; P P, P' P', parallels along which the cone coincides with the sphere.

invented which aim at giving a truer perspective view of the world. In these the meridians are shown converging to the north or to the south, according to whether the map is of an area north or south of the equator. The gnomonic projection is based on the assumption that the eye surveying the world is at its centre ; the orthographic projection, on the assumption that the eye surveys the world from an infinite distance ; the stereographic projection, on the assumption that the eye is on the surface of the globe opposite the surface to be mapped. The equidistant, or globular, is a modification of the orthographic and stereographic projections. The different results for the same area mapped on these four projections are shown in Fig. 43. Mollweide's "homalographic" projection (used in Figs. 20, 21, and 23) is an equal-area projection in which the complete circle on the map equals the world hemisphere, and the parallels are drawn so that the zone enclosed by them has the same relation to the circle as the actual zone on the earth has to the hemisphere. In Sanson-Flamsteed's projection the parallels are drawn at their true distances from the equator, and the distances between meridians are correct at each parallel. There are other, more involved, projections ; but enough has been said to indicate the principles on which countries and continents are mapped.

BOOK LIST

General. *The Physical Basis of Geography*, W. S. Wooldridge and R. S Morgan (Longmans) ; *Physical Geography*, P. Lake (C.U P.) ; *Principles of Physical Geography*, F. J. Monkhouse (Univ London Press) ; *The Ocean*, F. D. Ommaney (O.U P.)

Climate. *Climate Through the Ages*, C. E P. Brooks (Benn) ; *Climates of the Continents*, W. G Kendrew (O.U.P.) ; *The Climate of the British Isles*, E G Bilham (Macmillan) ; *Climate and the British Scene*, G. Manley (Collins) ; *Climate in Everyday Life*, C E. P. Brooks (E. Benn).

Cartography. *Maps and Survey*, A. R. Hinks (C.U P.) , *A Key to Maps*, H. S. L. Winterbotham (Blackie) ; *Map Making*, F Debenham (Blackie) ; *Map Projections*, G. P. Kellaway (Methuen) ; *Map Reading Made Easy*, Eason and Philip (Philip).

RADIO AND TELEVISION

THIS *Course presents a simple yet technically satisfactory summary of the theory and practice of radio to-day. Included are the basic theories of radio valves, tuned circuits, and the carrier wave, and techniques used in amplification, detection, and output stages. Special attention is given to amplitude modulation receivers of the tuned radio frequency and superheterodyne types, and to frequency modulation receivers. The principles of television transmission and details of television receivers are explained.*

12 LESSONS

LESSON 1

Introductory Theory

THE operation and manner of use of valves in the transmission and reception of radio and television signals form the subject matter of this Course, and the Lessons require that the student should know something of the nature of electricity and of the electron. Reference therefore should be made to the Course on PHYSICS in Vol. 2.

A valve for use in battery radio sets operates by virtue of its filament, a fine wire which, when heated by the passage through it of a current, emits from its specially prepared surface a continuous supply of electrons. Filaments are rated to consume from ·06 to ·3 amps at 2 volts in sets using a 2-volt accumulator as low tension supply, or ·025 to ·15 amps at 1·4 volts in valves used in all-dry receivers, where the low tension supply is derived from a dry cell.

Cathode and Anode

In mains valves the electron-emitting surface, usually a coated metal sheath, is heated by a fine wire placed within it. The sheath, or *cathode*, is electrically insulated from the heater, and in this fact lies the chief difference between battery and mains valves. They have similar characteristics, and although the diagrams which follow will for the most part indicate battery valves this is only for the sake of simplicity. The circuits apply to both types of valve.

By the application of a positive voltage to another electrode within the glass or metal bulb, the electrons can be attracted through the evacuated space to this second electrode, or *anode*. When a negative voltage is applied to the anode, the flow of electrons to it is stopped, *but not reversed*, because the anode, being neither hot nor specially prepared, does not emit electrons. Because the electrons, the movement of which constitutes a current, can pass through the space between the electrodes in one direction only, the whole device is called a *valve*.

Function of the Grid

The valve is used for rectification and detection ; there can be no amplification without the introduction of a third electrode, called the *grid*. The grid consists of an open mesh of wire through which electrons bound for the anode have to pass ; its function is to assist or retard, according to the voltages applied to it, the flight of electrons through the valve. Its action in this respect can be seen from the curves of Fig. 1, in which the current to the anode (I_a) is plotted vertically and the voltage applied to the grid (E_g) plotted horizontally. A curve is taken for each of several fixed voltages on the anode ; these voltages (E_a) are marked against each curve.

The circuit-diagram inset shows how such curves are taken ; a positive voltage, set at the right value by the aid of the voltmeter E_a, is applied to the anode of the valve. To provide continuous variation of grid-voltage there is connected across the 9-volt grid battery a potentiometer P, the moving arm of which is joined to the grid. A second voltmeter E_g records the voltage on the grid, and the current flowing to the anode for each successive setting of this is read off from the milliammeter I_a. Voltages E_g and E_a are measured between grid or anode and the *negative* end of the filament.

For any fixed anode voltage the anode current rises as the grid is made more positive. At $E_a = 150$, for example, I_a is 3·65 mA when $E_g = -4$, rising to 6·9 mA when $E_g = -2$. Making the grid less negative by 2 volts has allowed electrons representing an extra 3·25 mA to pass through it to the anode. The grid exercises very effective control over the electron-stream, the numerical extent of this control being about 1·6 mA per volt for these particular conditions of operation. The control of grid over anode current is conventionally expressed in milliamps per volt (expressed as microamps per volt in the U.S.A.) and is called the mutual conductance g_m.

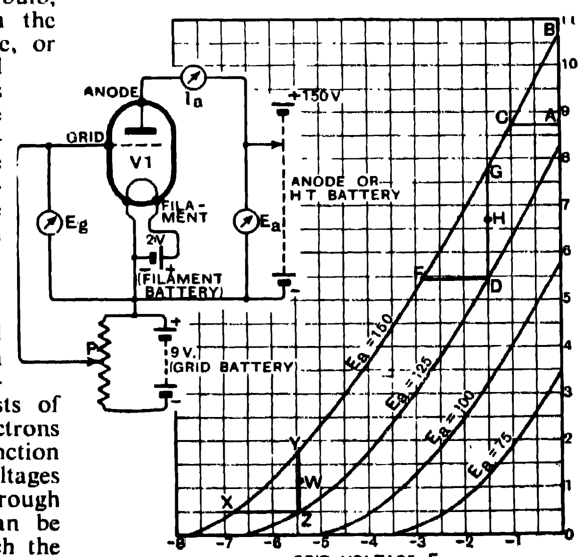


Fig. 1. Characteristic curves of a triode.

The value of g_m depends on the voltages applied to the various electrodes ; at $E_a = 75$, $I_a = 0{\cdot}15$ mA for $E_g = -3$, and 0·75 mA for $E_g = -2$. Here the mutual conductance is only 0·6 mA/V. For this, as for all valves, it is highest when the current is high ; taking g_m from E_g -1 to at $E_a = 150$ the figure rises to 2·0 mA/V. (AB/AC). Since the valve amplifies by virtue of the control exercised by the grid over the electron stream, a high value of g_m implies high amplification.

The ratio AB/AC defines the average slope of the curve over the range CB : for that reason mutual conductance is often called *slope*, and one speaks of a valve with a large value of g_m as a " high-slope valve."

Other Valve Characteristics

Draw a pair of lines GD, FD, as though to determine g_m over the range GF, but choosing D so that it falls on a curve relating to another anode voltage, and some more useful information about the valve can be gained. GD shows the change in anode current that results when E_a is dropped from 150V. to 125V., leaving E_g unchanged. At D, $I_a = 5{\cdot}45$ mA, while at G, $I_a = 7{\cdot}8$ mA, a change of 2·35 mA for 25V. This corresponds to a resistance of 25/0·00235 = 10,600 Ω.

This resistance is that which the valve would offer to an alternating voltage swinging the anode between the limits 125V. and 150V., that is, having a peak value of 12½V. and being superimposed on a steady anode voltage (from the battery) of 137½V. (point H). The resistance thus found is called the "anode a.c. resistance" or " impedance " of the valve. (symbol r_a).

It is to be noted that r_a, like g_m, depends on the operating voltages ; over the range YZ r_a turns out to be 25/0·00127 = 19,700 Ω. Neither this value nor that previously found has any necessary relationship to the d.c. resistance of the valve, expressed as E_a/I_a ; without altering E_a, I_a may be given almost any value by adjustment of E_g, each leading to a different value for the d.c. resistance. In practice one is not concerned with the d.c. resistance of a valve ; it has been mentioned here merely to draw the necessary distinction between it and the all-important resistance r_a to alternating currents.

Amplification Factor

The line FD on Fig. 1 represents the change in grid-voltage, in this case 1·37V., necessary to hold the anode current steady while altering the anode voltage by 25V. The grid-voltage exerts 25/1·37 = 18·2 times as much influence on the anode current as does the anode voltage ; this ratio is called the *amplification factor* μ of the valve. Unlike g_m and r_a, μ is virtually independent, *in a triode*, of the operating voltages. From XZ, for example, $\mu = 25/1{\cdot}35 = 18{\cdot}5$, which is virtually the same value as found at FD.

The three properties of the valve, μ, g_m, and r_a, are interrelated thus : $g_m = \mu/r_a$. It follows, since μ does not vary, that changes in g_m with operating voltages are due to changes in r_a.

Amplifiers

The simplest type of amplifier is illustrated in Fig. 2. It consists of a valve and a resistor, the circuit being so arranged that the anode current passes through the resistor, which is called the *anode load.* The alternating voltage set up across the load when the anode current varies in response to a signal applied between grid and filament, can be many times greater than the grid signal. The ratio of these two voltages E_{out}/E_{in} is called the *stage gain* or, more simply, *gain*. One of the properties of an amplifier of this type is that at low frequencies the gain is constant over a wide frequency range. This is one of the requirements of an audio-frequency amplifier, and therefore this circuit is extensively used for audio-frequency amplification.

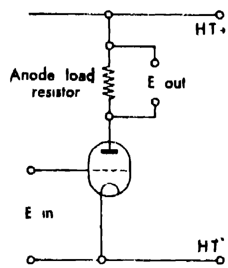


Fig. 2. Essential features of an audio-frequency amplifying stage.

Circuits of this type are not suitable for amplifying very much higher frequencies such as carrier frequencies (*see* Lesson 3). Such amplifiers are called radio-frequency amplifiers and they are required to amplify a comparatively narrow band of frequencies. A simple resistor does not make a suitable anode load for this purpose, and it is customary to use a tuned circuit consisting of an inductor (i.e. a coil) in parallel with a capacitor. Circuits of this type are frequently encountered in radio, and it is essential that the student should know

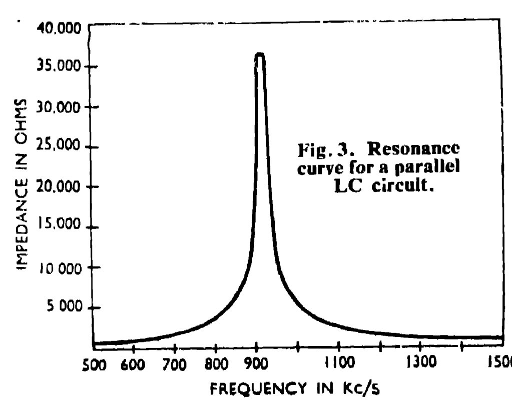


Fig. 3. Resonance curve for a parallel LC circuit.

something about them. The next paragraphs summarise the chief characteristics.

The significant feature of the parallel circuit of inductance (L) and capacitance (C) is that its impedance varies markedly with frequency. This variation is shown in Fig. 3, for a typical circuit ; the impedance is low over most of the frequency band but rises to a sharp maximum at one particular frequency. This is called the *resonance frequency*, and the LC circuit is said to be *tuned* to this frequency. At the resonance frequency the impedance is very high, around 36,000 ohms, for the combination illustrated, but at most other frequencies it is very low. If such a circuit is used as the anode load of valve, the gain of the amplifier so formed (Fig. 4) is a maximum at the resonance frequency (because of the high impedance), but it is very low at other frequencies. So it can be said that such an amplifier responds best to a narrow band of frequencies centred on the resonance value. Circuits of the basic form of that in Fig. 4 are extensively used in radio-frequency amplifiers. But for a reason which is explained in Lesson 5, it is customary to use valves more complex than triodes.

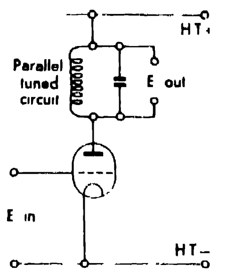


Fig. 4. Essential features of a radio frequency amplifying stage.

Radio-frequency amplifiers are used in receivers. Here it is necessary to be able to shift the resonance frequency at will, in order to tune the receiver to the desired transmission. This can be done either by varying the inductance or the capacitance, the resonance frequency f_c being related to those quantities according to the equation :

$$f_c = \frac{1}{\sqrt{(LC)}}$$

One way of varying the inductance, sometimes used for tuning, is to move a magnetic core along the axis of the coil, the inductance being a maximum when the core is at the centre of the coil. The cores are made of iron in the form of very fine powder or dust, which is mixed with a glue so that it can be moulded into a definite shape. More usually, tuning is effected by varying the capacitance in the circuit, variable capacitors consisting of a set of parallel vanes, approximately semi-circular in shape, which on rotation can be made to mesh with (but not touch) a similar set of fixed vanes.

LESSON 2

Microphones and Loudspeakers

In the preceding Lesson, valves, resistors, and tuned circuits were briefly dealt with. These are essential components from which radio transmitters and receivers are constructed. The way in which sound waves are converted into electric signals, and how at the other end of the broadcast chain the reverse process is accomplished, is now to be considered.

A speaker, in producing his words, sets up vibrations in his organs of speech, and as these are in contact with the air, this also is set into vibration. In the form of invisible air waves, the speech is carried to the ear of any listener ; the movements of the air impinge on his ear-drum and, by moving it, stimulate certain nerves to transmit to his brain the words of the speaker.

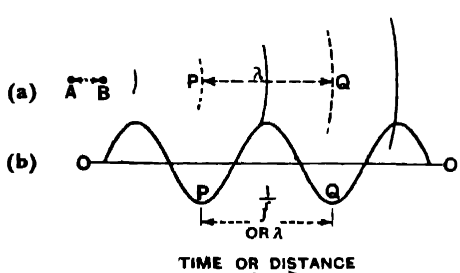


Fig. 5. (a) Waves sent out in air by vibrating string ; full line = compression ; dotted line = rarefaction. (b) The rise and fall of pressure at any one point plotted against time, or the distribution of pressure over a distance of 2½ waves at one instant.

Sound-waves

The keynote of the process is vibration. Consider what happens when a solid object, such as a fiddle-string or a loudspeaker diaphragm, vibrates in air, as in Fig. 5a. A and B indicate the end view of a vibrating string at the two extreme ends of its range of movement ; the end moves rapidly from left to right and back again between these limits. Its distance on either side of its central (non-vibrating) position at any instant can be indicated by the sine-wave of Fig. 5b.

In moving towards B the string pushes and compresses the air before it, the strength of the push dying away as the string slows up to reverse direction on reaching B. On the reverse travel it pushes air the other way (to the left), leaving behind it a momentary partial vacuum on the B side. Reversing direction again at A, it gives another push to the air on the right, and the process continues indefinitely. Like waves on the surface of water, the alternate

compressions and rarefactions of the air travel outwards from the string; they are sound waves. On arrival at a human ear they deliver to it alternate pushes and pulls at the same rate as those given by the string to the air. The pitch of the note heard is controlled by the rapidity of vibration, that is, by the number of complete travels from A to B and back again made by the string in each second, or by the number of complete waves per second in Fig. 5b.

Determining Wavelength

If the frequency of the note is 330 cycles per second (usually written c/s), the first compression-wave travels for 1/330th second before the next leaves the string. Since the rate of travel of sound in air is 330 metres per second (a metre is 39·4 inches), it will have moved just one metre. The second wave will follow at one metre's distance behind the first. The wavelength of this note, in air, is thus one metre.

If the frequency had been 660 c/s instead of 330, the first wave would have had only half as long a start on the second; the wavelength would then have been ½-metre. In general, wavelength λ (P—Q, Fig. 5) equals velocity divided by frequency; for sound in air, we can use the formula $\lambda = 330/f$ metres.

Sound waves have a limited range in air and are usually sent over great distances by first making electrical copies of them, i.e. by producing electric currents with the same shape as the sound waves. These currents can be transmitted over virtually any distance, either along a wire, as in telephone systems, or by radiating them from an aerial, as in radio broadcasting. Both methods require a device for converting sound signals into electrical signals, i.e. a microphone.

Telephone Systems

One type of microphone consists of two metal disks separated by loosely packed carbon granules. When sound waves move the thin diaphragm forming the front disk, the degree of perfection of contact between these granules is altered, so varying the resistance of the microphone. If a current is passing through the microphone all the time, then when speech waves strike the diaphragm, the current will vary in such a way that its difference at any instant from the normal steady value will represent the air pressure at that instant.

The current will take up the wave-form of the sound, and the curve of Fig. 5 will serve to represent the variations of the current about its normal value, OO. With more complex wave-forms than this, which represents a pure note, the process is the same, and even the involved variations of air pressure set up by speech are faithfully transformed into electric currents, which mirror them precisely.

This type of microphone is extensively used in telephone systems, but its quality is not good enough for use in broadcasting. For the latter it is customary to use moving-coil or ribbon microphones. Both rely for their operation on the same fundamental principle: that a voltage is generated across the ends of a conductor when this is moved across a magnetic field. The amplitude of the voltage so created is directly proportional to the speed at which the conductor is moved.

Ribbon Microphone

Fig. 6 shows in simplified form the construction of a ribbon microphone. It consists of a very thin corrugated aluminium ribbon suspended between the pole pieces attached to a permanent magnet. The ribbon vibrates in sympathy with any sound waves which strike it, and voltages of similar wave-form are set up between the ends of the ribbon. These voltages are very small but are stepped up to greater value by a transformer usually included in the case of the microphone, the outline of which is shown dotted in Fig. 6.

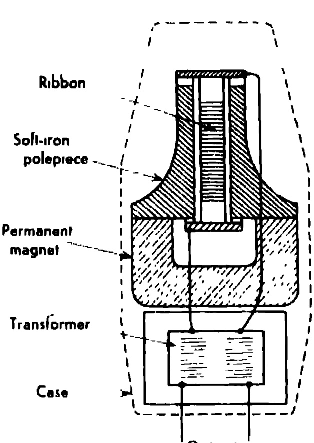


Fig. 6. Essential features of a ribbon microphone.

Moving-coil Microphone

The construction of a moving-coil microphone is shown in Fig. 7. This has a diaphragm in the form of a circular domed disk of aluminium which is reasonably free to move, being attached to the body of the instrument (shown solid) by a flexible suspension of corrugated aluminium. The diaphragm can thus vibrate under the stimulus of any sound waves which strike it. To the diaphragm is attached a coil of wire situated within the field of a permanent magnet. As the coil moves in the magnetic gap, voltages are induced in it, these constituting the microphone output. The output is greater

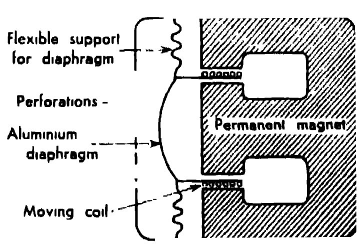


Fig. 7. Essential features of a moving-coil microphone.

than that of the ribbon microphone, because it is magnified by the number of loops or turns of wire in the moving coil. It is usual to step up the output still further with the aid of a transformer.

The shape of the magnet system of a moving-coil microphone is worthy of further description, because it is similar to that used in moving-coil loudspeakers. One pole of the magnet is cylindrical in shape and situated inside a hole in a soft-iron plate, which forms the other pole. Thus the two poles are very close together, and an intense magnetic field is produced in the air gap between the two where the moving coil is situated.

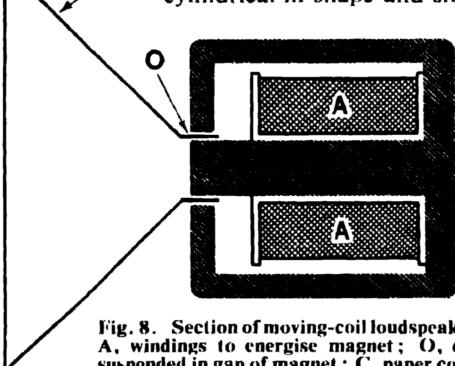


Fig. 8. Section of moving-coil loudspeaker. A, windings to energise magnet; O, coil suspended in gap of magnet; C, paper cone, supported around outer edge; baffle is indicated by broken line.

Moving-coil Loudspeaker

If audio-frequency currents are passed through the coil of a moving-coil microphone, the latter will reproduce them as sound waves. The currents produce a magnetic field inside the coil, and this reacts with the field due to the permanent magnet to produce movement of the coil and hence of the diaphragm. But the microphone does not make a very good loudspeaker, and this is due mainly to the small size of the diaphragm.

Usually loudspeakers have larger diaphragms —up to 16 inches in diameter, the most popular size being 5 to 8 inches diameter. Diaphragms are almost invariably of paper, and the construction of a typical moving-coil loudspeaker is illustrated in Fig. 8. This shows a loudspeaker with an energised magnet, i.e. one in which it is necessary to pass a steady current through field windings A in order to produce the magnetic field in the gap. Most modern loudspeakers have permanent magnets.

Frequencies in Music

Reference to the piano keyboard, Fig. 9, on which are marked the frequencies of the various notes in cycles per second, will reveal that for fullest reproduction of all musical notes, including harmonics, frequencies from 20 to at least 10,000 c/s must be handled by the speaker. Modern amplitude-modulated (a.m.) receivers reproduce only up to about 4,000 c/s.

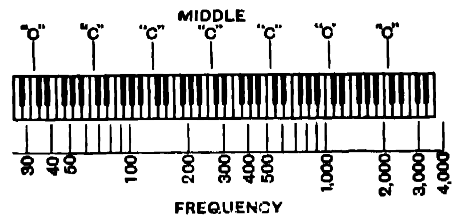


Fig. 9. Musical scale referred to in the text.

These are called low or audio-frequencies and are represented throughout this Course by the initials a.f.

At the lowest frequencies, movement of the diaphragm is so slow that air pushed forward has time to get round to the region of reduced pressure behind it, and, unless prevented, it does in fact do this, so that the energy available fails to set up a sound wave at these frequencies. The loss of bass that results can be avoided by making the length of the path from front to back of the diaphragm approach the wavelength of the low notes in question. For this the speaker is mounted behind a " baffle " (as in Fig. 8), consisting of a flat board or a cabinet with a hole fitting closely round the outer rim of the loudspeaker cone.

LESSON 3

The Carrier Wave and its Modulation

The musical scale, Fig. 9, shows that audible notes have frequencies up to 10,000 c/s or more, while the upper limit of audibility (bat's squeak) is round about 25,000 c/s ; 1,000 c/s is known as 1 kilocycle per second (written 1 kc/s.).

The most direct method of radio transmission would be to convert into currents, by means of a microphone, the music played in the studio, subsequently amplifying these currents and passing them to an aerial for radiation into space. If this were done, there would be no means of tuning-in one station rather than another, because all would have to radiate currents covering the whole musical range, and an adjustment of the receiver that was right for

one would be right for all. A further difficulty would be that higher frequencies are radiated far more efficiently than low, which at once suggests that if frequencies even higher than the highest of the audible range were to be sent out, they would travel long distances even if the power behind them were quite small.

Radio transmission is based on this latter conception, the frequencies used for sound broadcasting ranging from 30 kc/s to 100,000 kc/s (100 Mc/s). Such frequencies are called high or radio-frequencies. They are represented here by the initials r.f., to distinguish them from the lower frequencies in the a.f. spectrum.

Transmission Apparatus

In the simplest form of transmission, a continuous *carrier wave* is radiated from an aerial. The apparatus used for transmission consists fundamentally of a powerful source of

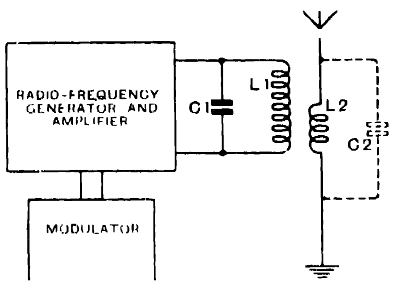


Fig. 10. Showing how radio-frequency currents are conveyed to an aerial for radiating. L2 is turned by the capacitance between aerial wire and earth, shown dotted at C2. Large currents pass through L1.

alternating current at a very high frequency, coupled in a suitable manner to an aerial. A scheme showing a possible coupling is given in Fig. 10. Here the high-frequency currents from the generator are fed into the circuit L_1C_1, which is tuned to the frequency of the generator by suitable choice of inductance and capacitance. Large currents pass through L_1, and this is so disposed in relation to L_2 that the alternating magnetic field set up by the passage of the current through the former cuts the latter, thereby inducing in it a voltage of the same frequency. These two coils are said to be *coupled*, because a current in one induces a voltage in the other.

L_2 is joined between aerial and earth, and forms with them another tuned circuit. The capacitance tuning L_2 is provided by the aerial-earth system, which acts as the two plates of the dotted capacitor C_2. L_2 is given an inductance that tunes the aerial to resonance with the generator.

The large current flowing in this tuned aerial circuit develops a large voltage between aerial and earth. The variation of voltage on the aerial with time can be represented by the curve of Fig. 11a, typical of all alternating-current phenomena. This rhythmic variation of voltage sets up disturbances in space, causing a series of rhythmic electrical pulses to be sent out.

If the time occupied by each cycle is one-millionth of a second (f = 1 Mc/s), the first pulse will have been travelling for this time before the second leaves the aerial. A disturbance in the ether travels at the rate of 300 million metres per second (186,000 miles per second, the speed of light), and if f = 1 Mc/s, the first will be 300 metres away when the next starts: the wavelength will be 300 metres.

Frequency Ranges

As with sound waves, one can use a simple formula for finding the wavelength of a radio wave of any frequency; the formula is $\lambda = 300{,}000/f$ metres (f in kc/s). "Medium-wave" broadcasting occupies the range 1,600 to 550 kc/s (187·5 to 550 m.). "Long-wave" broadcasting runs from 300 to 150 kc/s (1,000 to 2,000 m.).

Short waves can be considered as ranging from 6·0 Mc/s (50 metres) to 30 Mc/s (10 metres).

The frequency range 40–70 Mc/s is known as Band I and is allocated to television services. Above that the next broadcasting band is Band II, 87·5–100 Mc/s, reserved for frequency-modulated sound transmissions (the nature of which is described later). A further television band, 174–216 Mc/s (Band III), completes the spectrum of radio frequencies at present used for broadcasting. Higher frequencies will doubtless be brought into use in the future, possibly for colour television.

The continuous wave radiated into space in the way described can be robbed of its energy by any conductor it may pass on its travels, the energy lost to the wave appearing as current, and eventually heat, due to resistance-losses, in the conductor. If this latter happens to be an aerial wire, the currents can be made audible by a suitable wireless receiving installation.

Modulating the Carrier Wave

Neither music nor any other intelligible message can be conveyed by a continuous wave of constant amplitude; this wave really does no more than establish a link between transmitter and receiver, for which reason it is usually called a carrier wave. When it is interrupted by being broken up into short and long periods of transmission, the dots and dashes of the Morse code can be sent; this is one form of radio-telegraphy. For music or speech, something a little less drastic than complete interruption is required.

Taking the simplest case, let us suppose it is desired to make the continuous wave carry a single pure musical note, the wave-form of which

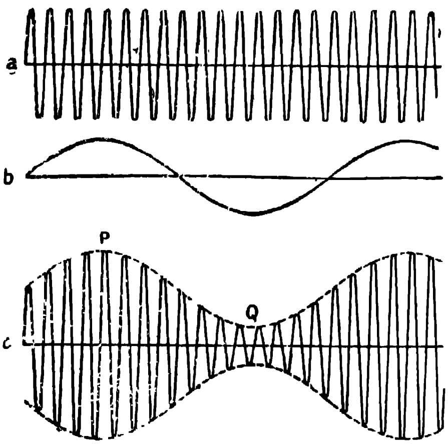


Fig. 11. Diagram illustrating how a continuous wave is modulated by a vibration of low frequency. The unmodulated carrier is shown at (a), the low frequency to be transmitted at (b), and the modulated carrier bearing the impress of (b) is given by the composite wave (c).

is shown in Fig. 11b, drawn to the same scale of time as Fig. 11a. Many radio-frequency cycles occur in the time of one audio-frequency cycle. Complete interruption of the carrier being too drastic, nothing remains but *partial* interruption, which can be interpreted as a change in intensity. Fig. 11c shows the carrier current at *a*, varied in amplitude at the frequency of the musical note at *b* ; the complete combination is a radio-frequency current still, and can be radiated as such ; but it will now carry with it in its variations of intensity the impress of the musical note that it is its duty to convey. The whole is called a *modulated carrier*, the note itself being referred to as the modulation.

When music or speech is being transmitted, the form of the modulation is that of an extremely complex and irregular wave ; but both in principle and in practice it is just as easy to modulate a carrier with the complex speech-currents from a microphone as with a current representing a single pure note.

Actually Fig. 11 shows far too few radio-frequency cycles to each audio-frequency cycle. A 1,000 c/s note on a 1 Mc/s carrier would have a thousand radio-cycles to each audio-cycle. A better, though less readily intelligible, representation would result if the whole space between the dotted lines showing the envelope of the wave in Fig. 11 were shaded, implying a radio-frequency far too rapid to follow.

Sidebands

The variations in amplitude of the carrier caused by the addition of the modulation can be expressed in another way, which is of considerable importance in receiver design. Both mathematically and physically, these variations in amplitude are exactly equivalent to the addition of new, less powerful carrier waves, called *sidebands*, differing in frequency from the original one by the frequency of modulation. The importance of this lies in the fact that a carrier modulated with musical frequencies up to 8,000 c/s loses its definite single frequency and becomes a band of frequencies 16 kc/s wide, centred on the frequency of the unmodulated carrier. Thus a station nominally transmitting on 1,000 kc/s may occupy all frequencies from 992 to 1,008 kc/s, and it is necessary that the receiver should shepherd the whole band, and not its centre only, through the set.

The Detector

Once in the set, the music brought by the carrier has to be made audible. Loudspeakers alone cannot do this, for they will not respond to the radio-frequency component, and so far as they are concerned the current at any instant is zero, the positive current (above the line in Fig. 11c) always being exactly balanced out by the negative current (below the line). That the currents thus balancing are sometimes large (at P) and sometimes small (at Q) does not matter ; the balance remains.

If it were possible to lop off half the wave by inserting in the circuit some contrivance that allowed the positive currents to pass while stopping the negative currents, there would remain an average positive current rising and falling at the frequency of the modulation. This current would follow the curve outlining the upper side of the modulation envelope. The loudspeaker would therefore reproduce the note originally superimposed on the carrier at the transmitting station.

The contrivance used to suppress half the wave in order to make the modulation audible is called a *detector* ; a thermionic valve is used for this purpose.

Frequency Modulation

In the type of modulation just described the *amplitude* of the carrier wave is swung above and below its unmodulated value by the modulating signal ; this is called *amplitude modulation*. In another type of modulation the carrier amplitude is kept constant and its frequency is swung above and below its unmodulated value by the modulating signal. The amplitude of the modulating signal is portrayed by the *extent* of the frequency change, and the frequency of a modulating signal is equal to the *number of swings* in carrier frequency which occur *per second*. This is *frequency modulation* (f.m.).

This system of modulation has the advantage over amplitude modulation in that receivers can be made insensitive to voltage fluctuations in the input signal and thus be unresponsive to

interference caused by electric motors, atmospherics, and other sources. F.m. is therefore particularly useful in cities, where man-made sources of interference abound. Frequency modulation of a carrier wave produces sidebands just as amplitude modulation does, but it produces them in greater numbers and they occupy a wider band-width. For this reason f.m. broadcasting is carried out on high carrier frequencies in Band II (87·5-100Mc/s) where there is room for the sidebands. In the U.S.A. the sound accompaniment for television programmes is also broadcast on f.m. Details of f.m. receivers are given in Lesson 10.

LESSON 4

Audio-frequency Amplification

THE basic features of a valve amplifying circuit were described in Lesson 1, where it was shown that one volt applied to the grid of a valve has the same effect on anode current as μ volts applied to the anode. When an alternating voltage V_g is applied to the grid there is in the anode circuit the equivalent of an alternating voltage μ times as great. It therefore becomes possible to replace the circuit of Fig. 12a, which shows a valve to whose grid a signal-voltage V_g is fed and in series with whose anode there is a resistance R, by the simplified circuit of Fig. 12b, which is very much more amenable to calculation.

The total alternating voltage across R and r_a is μV_g; that across R will be the fraction $R/(R + r_a)$ of the whole. For V_g volts applied to the grid, we obtain $\mu R V_g/(R + r_a)$ volts from the anode, representing a voltage amplification of $\mu R/(R+r_a)$ times. This stage gain will approach the value μ as R is made greater and greater. The result is that the stage gain A of a triode with a resistance load is given by :

$$A = \frac{\mu R}{R + r_a}$$

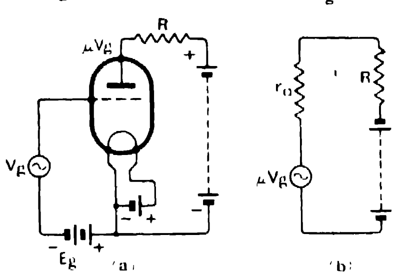


Fig. 12. (a) Simple amplifying stage; (b) circuit equivalent to (a), showing the anode circuit only.

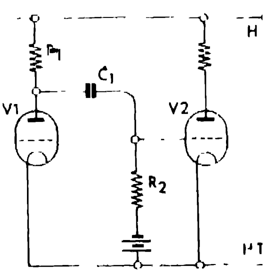


Fig. 13. Illustrating method of obtaining grid bias by use of a dry cell.

It might be thought that the input signal V_g could be applied directly between the grid of the valve and the negative end of the filament, and if the input signal is small this is sometimes done quite successfully. But if the signal is reasonably large—say more than 1 volt in amplitude—such a simple arrangement gives rather distorted results. On positive half-cycles of the input signal the grid collects electrons from the filament, causing *grid current* to flow in the source of input signal.

In flowing through the source resistance this current sets up a voltage which tends to make the grid negative, and reduces the effective input voltage at the valve grid. This does not occur on negative half-cycles of the input signal, because no electrons are collected by the grid and there is no grid current. As a result of grid current, therefore, positive half-cycles of the signal are not reproduced at their full amplitude and the valve output is distorted.

To avoid this distortion it is necessary to arrange that the grid is always negative with respect to the filament, even when the positive half-cycles of the signal are being performed. This is achieved by applying to the grid, in addition to the input signal, a steady potential which must be greater than the peak value of the largest-amplitude signal the valve is likely to be called on to amplify. This steady negative voltage is called the *grid bias*.

In older types of battery-driven receivers a separate battery, called a grid-bias battery, was used for providing these steady potentials, and Fig. 13 is a typical circuit. The battery is connected between grid and filament via a high-value resistor R_2, called a *grid leak*. This resistor is essential; without it, the small internal resistance of the battery would short-circuit the input to valve V_2. A typical value for a grid leak is 1,000,000 ohms, i.e. 1 megohm, written 1 MΩ.

Resistance-Capacitance Coupling

Fig. 13 illustrates another feature of audio-frequency amplifier design—the method of applying the output of one valve to the input of the next for further amplification. This is done by using a coupling capacitor C_1. The output of valve V_1 is in the form of an alternating voltage developed across resistor R_1. One end of R_1 is connected directly to the positive pole

of the h.t. supply, and the potential at this point is fixed. The voltage variations constituting the valve output thus appear at full amplitude at the other end of R_1, the end connected to V_1 anode. To transfer this voltage to the grid of V_2 requires a connection between V_1 anode and V_2 grid. A direct connection cannot be used, because this would apply the positive (h.t.) voltage at V_1 anode to V_2 grid in addition to the wanted alternating signal.

What is wanted here is a component which will transfer alternating voltages but block steady ones, and a capacitor is the obvious choice. The capacitance required depends on the resistance R_2, because these two components can be regarded as forming a potential divider across R_1; the larger R_2 is made, the smaller need C_1 be. If R_2 = 1 MΩ, C_1 can be 0·01 μF in an a.f. amplifier.

Automatic Bias

In mains-driven receivers and amplifiers it is inconvenient to use dry cells to provide grid bias, and the necessary voltage can be obtained automatically from the cathode current of the valve. In the typical circuit shown in Fig. 14a the cathode of the valve includes a resistor R_1 and a capacitor C_1, the valve grid being returned to h.t. negative by a grid leak R_2. In flowing through R_1 the valve current sets up a voltage which makes the cathode of the valve positive with respect to h.t. negative.

As the grid is returned to h.t. negative, the cathode is positive with respect to the grid: the grid is negative with respect to the cathode as in the battery bias circuit of Fig. 13. The value of cathode resistor required to give a wanted value of bias can be obtained directly from Ohm's law. If the bias required is − 2 volts and the valve anode current at this value of bias is 5 mA, the resistor value is given by:

$$R_1 = \frac{E_g}{I_a} = \frac{2}{0{\cdot}005} = 400 \text{ ohms}$$

Reducing Distortion

During operation of the amplifier the anode current varies in sympathy with the applied signal, and if C_1 were omitted the bias would vary too. Such variation of bias has the effect of reducing the gain of the valve, this being one form of negative feedback. It also reduces distortion, and where the highest quality is wanted and gain can be sacrificed, the circuit is used without the bypass capacitor C_1. Where maximum gain is essential, the capacitor must be included. Its reactance should be small compared with R_1 at the lowest frequency to be amplified; 50 μF is a common value in audio-frequency amplifiers.

A circuit of similar principles is used in modern battery sets to eliminate the need for bias cells. The automatic bias resistor is connected between l.t. negative and h.t. negative, and the grid leak for the valve requiring bias is returned to h.t. negative. The anode currents of *all the valves* in the receiver pass through the bias resistor and develop the required bias voltage across it.

Using a Transformer

Fig. 14b shows an alternative method of connecting the output of one valve to the input of the following valve in an audio-frequency amplifier. Instead of two resistors and a capacitor the circuit uses a transformer. The anode current of V_1 passes through the primary winding of the transformer, and in doing so induces a voltage across the ends of the secondary winding. This voltage has a wave-form similar to that of the current in the primary, and it is applied to the grid of V_2. R_K and C_K are automatic biasing components.

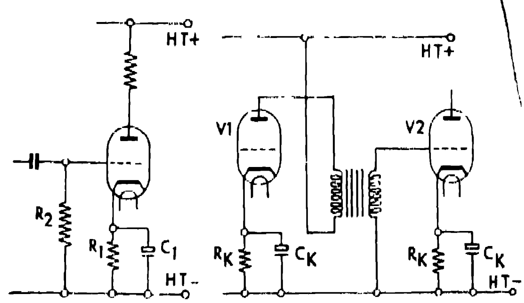


Fig. 14a (left). Method of obtaining grid bias by means of a cathode resistor. Fig. 14b (right). Inter-valve coupling by means of a transformer.

One of the advantages of this method of coupling is that it can in itself provide some amplification. For example, if the secondary winding has five times the number of turns on the primary winding, the secondary voltage is five times the primary voltage, i.e. five times the output voltage of valve V_1. Where V_1 and V_2 have equal gains of say 20, the overall gain of the amplifier is 20 × 20 × 5 = 2,000. With RC-coupling the gain would be only 20 × 20 = 400; but the three components of an RC-coupling circuit are cheaper than a transformer.

LESSON 5

Radio-frequency Amplification

THE process of magnifying the radio-frequency voltage induced in an aerial when a carrier wave strikes it is called *radio-* or *high-frequency amplification.*

Every receiver begins with a tuned circuit, because this provides both a certain selectivity and some magnification of the received voltage. In Fig. 15 the tuned circuit L_1C_1, coupled to the aerial coil which carries the aerial currents due to all transmitters within range, selects from the mixture and magnifies that which has the desired frequency. As the figure shows, the input voltage to the valve V_1 is that developed across the variable tuning capacitor C_1.

From the basic circuit of Fig. 4 it would appear that a satisfactory r.f. amplifier could be constructed by using a second tuned circuit L_2C_2 as the anode load of a triode, as suggested in Fig. 15. But such a circuit (if constructed) bursts into oscillation whenever the two circuits L_1C_1 and L_2C_2 are adjusted to resonate at the same frequency. Energy is fed back from the anode circuit to the grid circuit in sufficient quantity for the amplifier to be capable of supplying its own input.

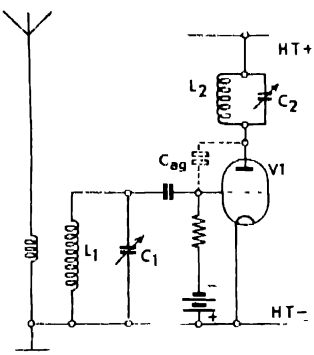


Fig. 15. Elementary form of r.f. amplifier which is unsatisfactory because of instability caused by the anode - grid capacitance (shown dotted).

The transfer of energy can occur via mutual inductance between L_1 and L_2 but even if the two inductors are perfectly screened one from the other the instability still persists. It occurs inside the valve and by way of the capacitance between the anode and the grid of the triode. This capacitance is very small, e.g. 2 pF, but it can provide sufficient feedback of energy to cause oscillation.

Screen-grid Valve

To overcome this instability, the *screen-grid valve* is used. Between signal grid and anode there is interposed a screen of fine-mesh gauze which, in use, is connected to filament by a capacitor offering negligible impedance to the radio-frequency currents. Energy fed back from the anode is trapped by the screen and shunted harmlessly through this capacitor to filament, without being allowed to pass through the grid circuit on the way. By using for V_1 a screen-grid valve the circuit of Fig. 15 immediately becomes completely stable.

The screen of the valve, if kept at earth potential, would decrease the electron-flow to the anode so greatly that the amplification obtained would be very poor. It is therefore connected to a tapping (about 60v.) on the h.t. battery, giving it a voltage high enough to increase the electron-flow, while still being low enough to allow the anode to pull the bulk of the electrons to itself by virtue of its higher voltage (about 120v.).

Compared with a triode, a screen-grid valve has about the same value of mutual conductance, but its higher amplification factor, even though combined with a higher a.c. resistance, allows greater gain to be had from the stage as a whole.

Negative Resistance

The introduction of the second grid into the triode, resulting in the screened-grid valve or tetrode, made possible for the first time stable high-gain r.f. amplification. But it was soon discovered that these tetrodes had one disadvantage as far as r.f. amplification was concerned. At low anode voltages the anode emits secondary electrons, and as a consequence these valves develop a negative anode impedance, as shown by the portion AB of the dotted curve in Fig. 16a. This limits the output of the valve.

There are two ways of overcoming this kink of negative resistance. One is by constructing the valve with a large space between screening grid and anode. This is the method used in

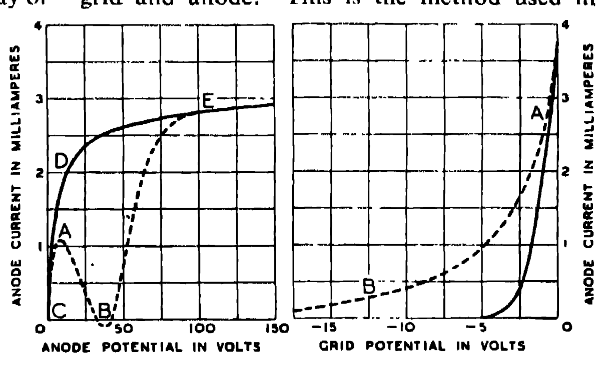


Fig. 16a. Anode current-anode voltage curve of tetrode (screen grid) valve, showing kink (dotted) of negative anode impedance, overcome by third grid, giving the pentode valve. Fig. 16b. Anode current-grid voltage curve of variable-mu pentode valve (dotted). Solid curve is of non-variable-mu pentode valve.

output tetrodes. The second is by introducing a third, earthed, grid between screening grid and anode, which gives the pentode valve. Such construction is used in pentodes for r.f. amplification and power output. The curve CDE in Fig. 16a is typical of the I_a - E_a characteristics for a pentode and a tetrode with critically-spaced electrodes. Note the complete elimination of the kink of negative resistance.

Variable-mu Valve

R.F. amplifiers can be used to amplify a weak signal to amplitudes suitable for use by a detector, or they can be required to handle a very strong signal when the receiver in which the amplifier is built is tuned to the local station. An r.f. valve, whether pentode or tetrode, may have an amplification factor of several thousands, which means that the valve can operate satisfactorily only on very small grid swings. If a large signal is applied, severe distortion inevitably results.

In modern radio practice this difficulty has been solved by the introduction of *variable-mu* r.f. valves. These are tetrodes or pentodes in which the spiral of wire which forms the control grid has been wound so that the pitch is wide one end and narrow at the other. As a consequence of this a small negative potential applied to the grid will completely stop electrons passing through the small meshes but not through the wide-mesh part. It takes a very large negative bias to stop the electrons passing through this part, and so the I_a E_a curve for a variable-mu valve has the shape shown dotted in Fig. 16b. The solid curve applies to a non-variable-mu or straight tetrode or pentode.

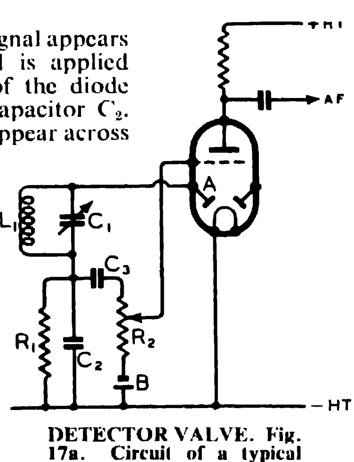
The mutual conductance or slope of the variable-mu valve varies along the curve, being great at small negative bias values and small at large negative values of grid bias. Small signals applied when the grid bias has been adjusted to point A will receive great amplification as in normal straight r.f. valves ; but if the valve is biased back to point B, the valve can accept a signal of 20–30 volts peak to peak value. Thus it is possible with such valves to control the amplification and the signal handling capacity simply by altering the grid bias. Hence the name variable-mu valve. These valves make the easiest and best kind of volume control.

LESSON 6

Principles of Detection

THE diode type of detector, or demodulator, is the most popular. A typical circuit for such a detector is shown in Fig. 17a. Here two diodes are combined with a triode a.f. amplifier, all in a single glass bulb. This type of valve construction, where several simple valve types are combined within a single glass envelope, is typical of the complex varieties now available.

The modulated radio-frequency signal appears across the tuned circuit L_1C_1 and is applied between the anode and filament of the diode A via the resistance R_1, and the capacitor C_2. Detected audio-frequency voltages appear across R_1, and are applied via the coupling capacitor C_3 and the volume control potentiometer R_2 to the grid of the triode a.f. amplifier. The coupling capacitor C_3 is necessary to allow of the potentiometer being connected to the grid bias battery B.



DETECTOR VALVE. Fig. 17a. Circuit of a typical diode detector. See also Fig. 17b in next page.

Diode Detector

To appreciate the method of operation of a diode detector it is well to consider first the operating conditions when an unmodulated r.f. signal is applied to it. The circuit under consideration is that shown in Fig. 17b, in which the generator delivers a constant-amplitude alternating voltage. On positive half-cycles of the input signal the diode anode is made positive with respect to its cathode, and electrons are collected by the anode ; that is, current flows through the valve and into the capacitor C_2. The current in C_2 generates a voltage across it and, with proper design, this voltage is approximately equal to the peak value of the applied alternating input.

During negative half-cycles of the input signal the electrons emitted by the cathode are returned to it by the negative charge on the anode, and there is thus no current through the valve. C_2 therefore begins to discharge through the diode load R_1 but, if the circuit is working properly, the fall in voltage across C_2 during the time of the negative half-cycle is very small—usually about 5 per cent. of the

total voltage. This loss in charge is made good during the succeeding positive half-cycle when the voltage across C_2 is restored to its maximum value again.

So the process continues, the capacitor voltage being restored to its maximum value once during each cycle of the input signal. The voltage across C_2 has a ripple at the frequency of the input signal, due to the periodic partial discharges through R_1; but it is of small amplitude, and the voltage can be considered as about constant. Its value is equal to the peak value of the alternating input signal.

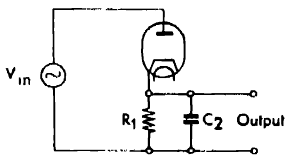


Fig. 17b. Fundamental circuit of a diode detector.

Suppose that the applied voltage is amplitude-modulated: the peak value rises above and falls below the unmodulated value in sympathy with the wave-form of the modulating signal. The voltage across C_2 is at all times equal to the peak value of the input signal, and hence this voltage, which is the detector output, rises and falls about the steady value which corresponds to the unmodulated carrier.

With an unmodulated carrier of 10 volts amplitude, the voltage across C_2 will have a steady value of 10 volts. If the carrier is 100 per cent. modulated, its amplitude varies between 0 and 20 volts peak value, and the diode output similarly varies between 0 and 20 volts. The detector output never reverses in polarity during modulation; it has the same sign at all times, but varies in amplitude with the same wave-form as the modulating signal. The output has an average value approximately equal to the unmodulated carrier amplitude. Use is made of this in automatic gain control circuits, described more fully in a later Lesson.

Drawbacks

Diode detectors work well in practice. It is virtually impossible to overload them; they give less distortion the greater the signal applied to them. Diodes occupy little space and it is easy to combine two of them with a triode or a pentode in one glass envelope. These are the reasons why diode detectors are invariably used in modern superhet receivers. But they have disadvantages: they do not amplify in themselves, and they offer a fairly low resistance to the tuned circuit which feeds them. They reduce its amplification and its selectivity, this being known as "damping" the tuned circuit.

Suppose we take an ordinary triode valve and connect it up as a diode detector, using its grid as a diode anode. The true anode we connect up as an a.f. amplifier as shown in Fig. 18. What will happen? The grid will function as a diode anode, and will detect as already explained. Audio-frequency potentials corresponding to the modulation wave-form will appear on the grid, and these will be impressed on the electron stream, and so the valve amplifies the audio-frequencies. Such an arrangement sounds ideal, far superior to a normal diode which has an amplification factor of less than one; but there are two drawbacks.

As previously explained, a diode detector develops a steady potential on which the audio-frequency output is superimposed, and this voltage is dependent on the magnitude of the signal applied to the diode. In the case of the leaky grid detector this steady voltage has to play the part of grid bias for the amplifying process of the valve, and the steady potential may not be quite the right value for grid bias purposes. In fact, only for one particular value

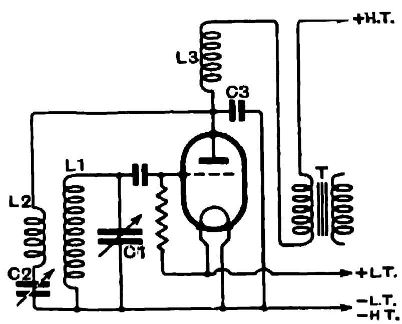
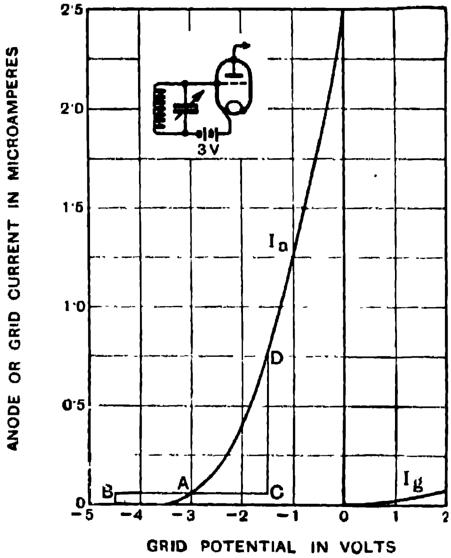


Fig. 18. Triode grid-detector with reaction. Adjustment of capacitor C2 neutralises detector damping on L1 C1, sharpening tuning until circuit is thrown into oscillation.

of signal strength can this steady voltage be correct as grid bias. This fact limits very severely the range of signal strengths which can safely be applied to a leaky grid detector, and the only safe plan is to apply fairly small signals to the valve. Leaky grid detectors give their best results on small signals, a result quite the opposite to that for diode detectors.

The second drawback is that leaky grid detectors damp the tuned circuit which feeds them even more than diode detectors, due in this case to the presence of the anode-grid capacitance. This difficulty can be overcome by the use of a valve with a very low value of anode-grid capacitance, such as a screened grid or r.f. pentode, or by the use of reaction. This important addition to a leaky grid detector is largely responsible for the enormous popularity which this type of detector once enjoyed.

In connexion with radio-frequency amplification (Lesson 5) attention was drawn to possible



ANODE-BEND DETECTION. Fig. 19. Circuit and curve for an anode-bend detector.

oscillation caused by energy fed back from the anode circuit of a valve to its grid. It was shown that if the anode and grid circuits are tuned to the same frequency, the anode-grid capacitance of a triode is sufficient to cause oscillation. If the anode circuit is not tuned, there is no oscillation, and the effect of the inter-electrode capacitance is to damp the input circuit severely. What is wanted to improve the performance of the leaky-grid detector is a circuit which offsets the damping due to the anode-grid capacitance and goes part of the way towards making the input tuned circuit oscillate. When this circuit is adjusted so that it just fails to oscillate, the damping is neutralised and the effective magnification of the input LC circuit can be considerably increased. This process is called *reaction*, *regeneration*, or *positive feedback*. Fig. 18 is an example of a circuit that can be used. This shows an ordinary grid detector in which the anode circuit contains a high-frequency choke L_3, the inductance of which is so chosen that it offers a low impedance to currents of speech frequency and a high impedance to high-frequency currents. The former travel on through the audio-frequency transformer T ; the latter pass to earth either through C_3 or the coil and capacitor L_2C_2.

L_2 is coupled to L_1, with the result that the passage through it of radio-frequency currents tends to build up the signal voltage already present in L_1. Control of this effect is achieved by adjusting the reaction capacitor C_2 ; this acts as a variable feed-impedance, and does not tune L_2 to the frequency of the signal.

As C_2 is increased in capacitance, the signal being received gets louder and louder, the tuning of L_1C_1 becoming sharper. Ultimately the tuning becomes sharp enough to make the reproduction very low-pitched ; reaction has then been pressed beyond its legitimate limit. The increase of sensitivity imparted to a receiver by the judicious use of reaction can be very great, especially if the detector, like that shown in Fig. 18, damps its grid circuit heavily. Therefore reaction has been very extensively used, especially in simpler, low-priced sets.

One of the disadvantages of diode detection is that the tuned circuit that feeds it has to provide the voltage driving the diode current, and there is loss of signal voltage, and flattening of tuning. This is avoided by anode-bend rectification.

This depends on the curvature of the E_g–I_a characteristic instead of on the curvature of the E_g–I_g characteristic. Circuit and curve for anode-bend detection are given in Fig. 19. When a carrier of 1·5 v. amplitude is superimposed on the steady 3 v. bias at point A (I_a = 0·06 mA) the anode current will swing in sympathy between zero and D (0·78 mA), giving a large increase in average current. This audio-frequency current can be converted into a voltage for transmission to the next valve by inserting a suitable impedance in the anode-circuit of the detector.

Unless the signal is too large, the region of grid current (Fig. 19) is never entered with anode-bend detection ; the tuned circuit therefore does not suffer damping from this cause. But the capacitance between anode and grid of the valve will still feed back energy tending to suppress the voltage applied to the grid. To avoid this it is usual to have a pentode valve.

LESSON 7

Output Stage in Modern Receivers

THE loudspeaker, connected in the anode circuit of the last, or *output* valve, requires power to operate it, because it has to do work in setting up sound-waves in the air. To provide this, power in reasonable quantities has to be taken from the h.t. supply ; in consequence, output valves are built to consume a fairly high anode current.

To obtain maximum power from a valve it is necessary to use the correct anode and grid voltages, and to use a loudspeaker of the correct impedance to give the valve its *optimum*

load. Details of this, worked out by a geometrical construction from the valve-curves, are set forth in the instruction slip issued with each valve. Leaving these calculations to the valve-makers, we will consider various types of output stage and their relative merits from the point of view of the designer and user of a receiver.

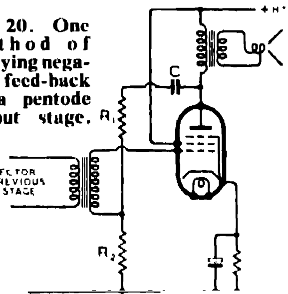


Fig. 20. One method of applying negative feed-back to a pentode output stage.

Triode and Pentode

The simplest output stage is provided by the triode valve. Its outstanding advantage is ease of handling, and it gives nearly full power over quite a wide range of loads. To set against this there is the disadvantage that the triode requires a larger signal to operate it than its usual competitor the pentode, and it makes rather inefficient use of the anode-circuit power supplied to it, converting only some 15 to 20 per cent. of it into audio-frequency power with which to drive the speaker.

The pentode has higher efficiency—it converts over 40 per cent. of the anode-circuit power supplied into speech-frequency output, and requires a smaller signal-voltage at its grid for full power ; but it gives much more distortion if the speaker loads it wrongly. With a moving-coil speaker, the impedance of which does not vary greatly with frequency, the pentode is satisfactory. Improved results can be obtained with pentode valves by connecting a tone-control circuit in parallel with the loudspeaker. This, in its simplest form, consists of a capacitor in series with a resistance.

Beam Output Tetrodes

Towards the end of Lesson 5 it was mentioned that it was possible to eliminate the " tetrode kink " by leaving a large space between anode and control grid. Modern radio technique makes extensive use of such valves for power output, for these tetrodes are superior to normal pentodes in performance. They are slightly more efficient and give less distortion. It is common practice in these valves to direct the electron stream emitted by the cathode towards the anode by earthed deflecting plates mounted within the valve. Such valves are called beam output tetrodes. They behave very similarly to pentodes : they have the same high impedance and require tone-controls for best results.

In Lesson 6 it was shown how the application of reaction, or regeneration, to a detector valve improved amplification but increased distortion by reducing the amplitude of the top notes. If reaction is applied negatively (giving " degeneration ") the opposite results will be obtained, i.e. amplification and distortion will be reduced. The use of degenerative or negative feedback is very popular in output stages, where it enables reproduction as distortionless as that from a triode to be obtained from a pentode or tetrode, whilst retaining the most attractive attribute of the latter – high efficiency.

One of the simplest ways of applying feedback consists in omitting the usual by-pass capacitor from automatic grid-bias systems. Another is shown in Fig. 20, where a potentiometer, consisting of the resistors R_1 and R_2, has been connected between anode and earth so that a fraction of the output voltage is applied to the grid of the valve via the secondary winding of the intervalve transformer.

Two-valve Output Stages

When more power is required for the loudspeaker than can be provided by a single valve, a second can be used in conjunction with the first as shown in Fig. 21, the arrangement being called *push-pull.* The signal voltage is split between the two valves, so that if at any instant the grid of one is made more positive by the signal, the other is made more negative. The resulting signal currents in the anode circuits of the two valves are therefore in opposition, but by being made to flow in opposite directions through the centre-tapped primary of the output transformer, their effect on the secondary is additive.

Because the steady anode-currents of the two valves are opposed, there is no permanent magnetisation of the core of T_2, nor is there any signal current flowing through the anode battery. The former allows of the use of a smaller transformer than would otherwise be possible, while the latter tends to prevent instability of the set as a whole.

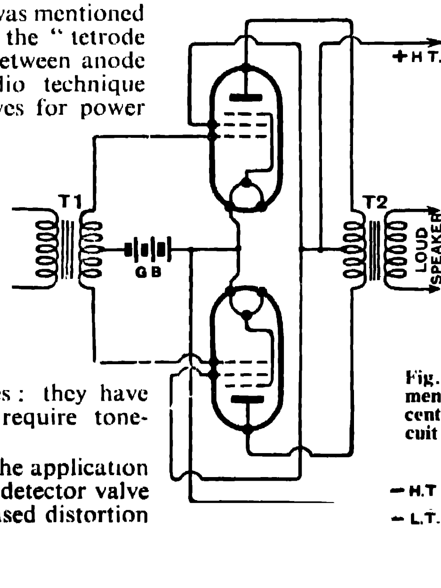


Fig. 21. Push-pull arrangement of two pentodes with centre-tapped transformer. Circuit for Q.P.P. differs only in voltage of grid battery.

When about double the usual bias is applied to the grids of V_1 and V_2 in Fig. 21, the anode current becomes negligibly small until a signal arrives. The alternating signal voltages make each grid in turn positive compared with its steady condition, and each valve in turn sends a pulse of anode current, in wave form like that of the applied signal voltage, through T_2. The sum of the alternate pulses is an alternating current, so that a normal signal voltage is induced in the secondary. Each valve deals with only one half-cycle of the signal.

The advantage of this ***quiescent push-pull***, or Q.P.P., is that the anode current taken from the h.t. supply is negligible in the absence of a signal, and is at any time only great enough to provide the required volume of sound in the speaker. In contrast, ordinary output valves take continuously a current large enough to cope with the strongest possible signal.

LESSON 8

Amplitude Modulation Receivers: Tuned Radio-frequency

HAVING considered the operations carried out in a "straight" receiver, namely r.f. amplification, detection, a.f. amplification, and power output, the reader is now in a position to investigate the circuit diagram of a complete receiver. Fig. 22 gives the complete circuit diagram of a three-valve two-waveband "straight" battery-operated receiver of the type known as t.r.f. (the initials signify the presence of a tuned radio-frequency stage).

This circuit comprises three pentodes, the first of which is a variable-mu valve functioning as an r.f. amplifier. The second valve, the detector, is an r.f. pentode of the "straight" or non-variable-mu variety. The third is an audio-frequency power output pentode.

The r.f. stage of the receiver includes all those parts of the circuit to the left of the line AB, Fig. 22. This receiver is designed to cover the long and medium wave ranges of 150–300 kc/s (1,000–2,000 metres) and 550–1,600 kc/s (187.5–550 metres) respectively. To achieve this, each tuned circuit is composed of two inductors, one of which (the larger) is shorted out by the wave change switch when medium-wave reception is wanted.

Screened Transformer

For example, in the first tuned circuit $L_3L_4C_2$, L_4 is shorted out by means of the switch S_2 when medium-wave reception is wanted. L_1 is mounted close to L_3 and serves to transfer the signal intercepted by the aerial to the first tuned circuit. The dotted line surrounding

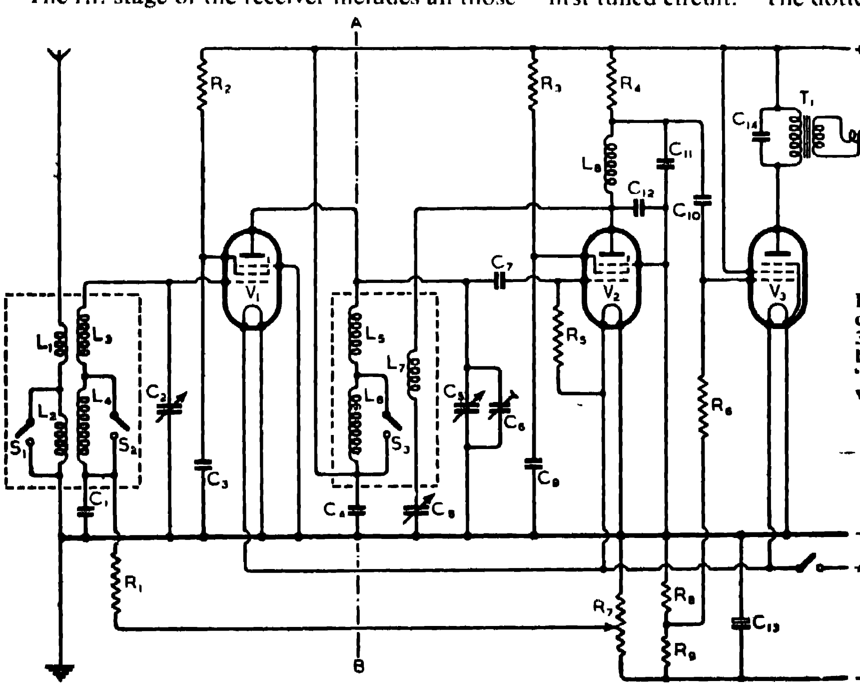


Fig. 22. Complete circuit diagram of 3-valve, 2-wave band, battery-operated "straight" receiver with tuned radio-frequency stage.

the transformer indicates that it is screened, i.e. mounted inside a metal box to prevent capacitive or magnetic interaction with other components in the receiver.

Notice that the inductor L_4 is not returned to earth but to a potentiometer R_7 via the r.f. filter R_1C_1, which has the function of preventing r.f. currents from straying into the audio-frequency section of the set. The potentiometer R_7 forms the volume control of the receiver and applies a controllable negative bias to the grid of V_1 in a manner to be described later.

The screen of V_1 is fed from the 120 volt h.t. line via the resistor R_2, the value of this being chosen to give the desired value of screen volts, usually about 60. It is commonly between 50 kΩ and 100 kΩ. The size of the capacitor C_3 must be such that it is a virtual short circuit to currents at radio-frequency. A suitable value is 0·1 μF.

The anode load of V_1 is the tuned circuit $L_5L_6C_5$, the values of the components being the same as for $L_3L_4C_2$. The switch S_3 closes with S_2 and S_1, and in a commercial receiver these three, together with the filament on-off switch S_4, would be operated by a single control knob with three positions—off, medium-wave reception, and long-wave reception. The 0·1 μF condenser C_4 has a purpose similar to that of C_6: it earths one end of the long-wave coil L_6 as far as r.f. currents are concerned, yet allows the coil to be returned directly to the h.t. line.

The Detector Stage

A straight r.f. pentode is used as a leaky-grid detector. R_3 and C_9 are the screen feed components with similar values to those used in the r.f. stage ; R_5 and C_7 are the grid leak and grid capacitor respectively, suitable values being 1 megohm and ·0001 μF. L_8 is an r.f. choke, which has a low reactance to a.f. currents but a high reactance to r.f. currents. It prevents r.f. currents from reaching the output stage and deflects them into the circuit L_7C_8, where their presence is beneficial, for this is the reaction circuit : the capacitance of the reaction capacitor C_8 controlling the degree of regeneration and hence the gain and selectivity of the detector stage. The a.f. voltage output of the stage appears across the anode load R_4. C_{11} and C_{12} are additional r.f. filtering condensers.

Automatic Biasing Arrangements

The a.f. output of the detector is fed immediately to the control grid of the output pentode V_3 via the coupling capacitor C_{10}. Bias is applied to V_3 by means of the 1 megohm grid leak R_6. The moving-coil loudspeaker is connected in the anode circuit of V_3 by means of the usual matching transformer T_1, C_{14} having the purpose of limiting the rise in moving coil impedance at high audio-frequencies.

We now come to the automatic biasing arrangements by means of which the two different bias values for the r.f. valve and for the output pentode are obtained without the use of additional dry cells from the main h.t. battery. The h.t. current of the whole receiver passes through the two resistors R_8 and R_9 connected between l.t. negative and h.t. negative. The value of R_8 is so chosen that the voltage drop across it is the correct grid bias for V_3. By returning the grid resistor R_6 to the junction of R_8 and R_9, V_3 is correctly biased. The value of R_9 is so chosen that the total voltage drop across R_8 and R_9 is the greatest value of bias likely to be required by V_1. Any desired fraction of this bias can be applied to V_1 grid by adjustment of R_7, which is connected across R_8 and R_9. To avoid negative feedback (*see* Lesson 4) the bias resistors are decoupled by a capacitor C_{13} of high capacitance. The receiver is sufficiently sensitive to give good reception from the stronger Continental stations.

LESSON 9

Amplitude Modulation Receivers : Superheterodyne

The superheterodyne (" superhet ") type of receiver has almost completely supplanted the " straight " type, a typical example of which is described in Lesson 8.

Briefly, the theory of operation is as follows. The wanted signal is " mixed " with (or " heterodyned by ") the output from an oscillator situated within the receiver. One result of this mixing process is that a new carrier is generated, the frequency of which is the difference between the frequency of the original carrier and that of the local oscillator. Suppose the wanted station is transmitting on 1,000 kc/s and the local oscillator is generating on 1,465 kc/s. The new carrier generated as a consequence of the mixing will be on 1,465 − 1,000 = 465 kc/s. The difference term is called the *intermediate frequency* (abbreviated to i.f.).

The Frequency Changer

The mixing and oscillating are carried out in a single valve called the frequency changer. The carrier generated at the intermediate frequency has impressed upon it the modulation of the wanted signal, so that if you follow the frequency changer by a complete straight receiver tuned to the i.f. you will hear the wanted programme as the output of the straight set.

The superhet receiver changes the carrier frequency of every station it receives into a single, new, and generally lower value, the i.f., which is then amplified, detected, and then amplified at audio-frequency as in straight receivers. All these processes are indicated in Fig. 23, in which the frequency changer is drawn as a single block. In the cheaper type of superhets the r.f. stage preceding the frequency changer is omitted.

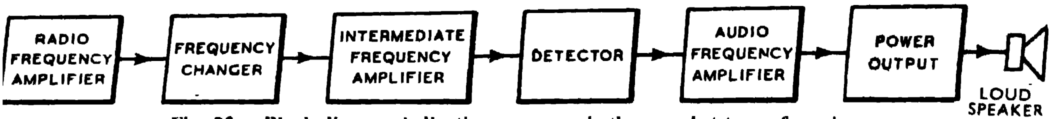


Fig. 23. Block diagram indicating processes in the superhet type of receiver.

Advantages of Superhet Principle

The advantages of the superhet principle are that it is a comparatively simple matter to design an r.f. amplifier to give high amplification, together with high selectivity, provided it has to work at only one carrier frequency.

The complete circuit diagram of an up-to-date superhet receiver for use on a.c. mains is given in Fig. 24. It represents a 3-wave-band, 4-valve (excluding rectifier) receiver. To the left of the line AB in Fig. 24 is the frequency changer, a multiple valve known as a triode-heptode. The right-hand side of this valve is a triode oscillator with a tuned anode circuit. The left-hand side, the mixer section, can be considered as an r.f. pentode with two additional grids, one of which is bonded internally to the oscillator grid and so impresses the oscillator frequency on the electron stream of the valve, thus giving rise to the mixing process.

The second additional grid is internally connected to the normal screening grid of the r.f. pentode, and serves to prevent interaction between the oscillator and signal-frequency circuits. The signal-frequency circuits which precede the frequency changer are similar to those preceding the r.f. valve in the straight set of Lesson 8, except that this set works over three wavebands, the additional short waveband being from 16·7 to 50 metres (6–18 Mc/s), and so the waveband switching is more complicated.

The receiver being described uses push-button control of wave-band switching as indicated in the diagram, which shows the medium-wave button pressed. The intermediate frequency of this set is 465 kc/s, which means that at all settings of the tuning control (the set uses ganged tuning capacitors, as in all modern sets) the oscillator frequency must be 465 kc/s higher than the signal frequency. As the receiver tunes from 150–300 kc/s, 550–1,600 kc/s, and 6–18 Mc/s, the oscillator frequency ranges are

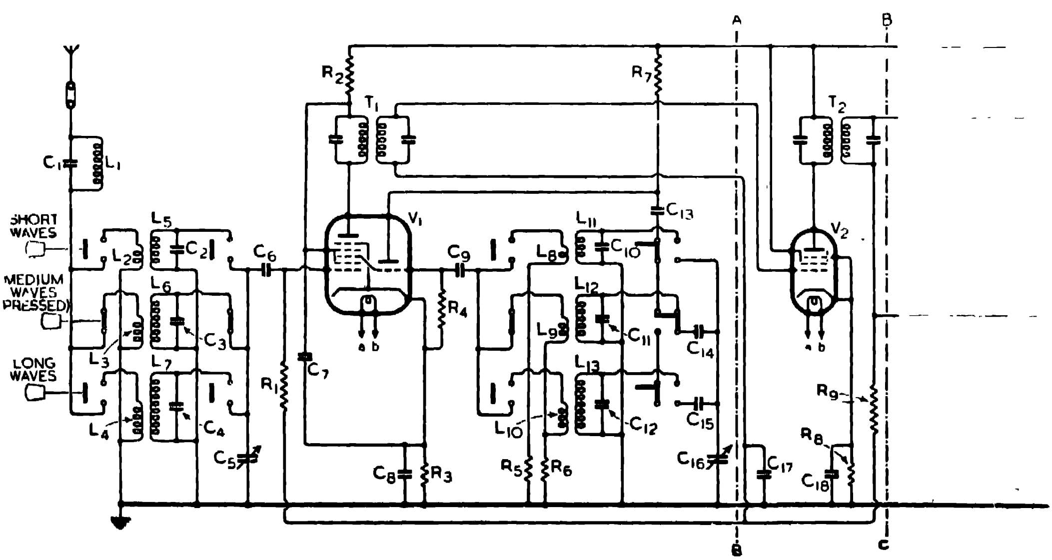


Fig. 24. Diagram (continued opposite) of a 3-wave-band, 4-valve (plus rectifier) mains-operated superhet receiver. Left of A B is the frequency changer. Between A B and B C is the intermediate frequency amplifier. Press-button wave-change switching is provided.

615–765 kc/s, 1,015–2,565 kc/s, and 6,465–18,465 kc/s, and at every setting of the tuning control the oscillator frequency must be just 465 kc/s higher than the signal frequency. This is called "tracking," and is achieved by means of the fixed capacitors C_{10}, C_{11}, C_{12}, C_{14}, and C_{15} which are carefully adjusted in value, as are also the oscillator tuning inductors L_{11}, L_{12}, and L_{13} so that this desirable result is secured.

Notice that the control grid of the frequency changer, which is specially wound to give the valve a variable-mu characteristic, is not returned to earth but to the a.g.c. line. This is a source of variable negative grid bias and its derivation will be discussed later.

Transformers

Between the lines AB and BC is a variable-mu r.f. pentode functioning as an i.f. amplifier. This part of the circuit is perfectly straightforward. Between V_1 and V_2, and V_2 and V_3 are the i.f. transformers T_1 and T_2. These consist of two identical tuned windings, both aligned at the correct intermediate frequency by the makers at the factory. These transformers are the heart of a superhet receiver, they are almost entirely responsible for its performance with respect to voltage gain and selectivity, and the performance of a superhet receiver is a considerable advance on that of a straight receiver. The stage gain of the i.f. amplifier is greater than any other stage of the receiver. A similar biasing arrangement exists for this valve as for V_1: the grid is returned to the a.g.c. line.

A diode detector and a triode a.f. amplifier are housed within the bulb of V_3 and the associated components are between the lines BC and CD. The diode detector circuit is quite normal. $R_{10}C_{19}C_{20}$ form an r.f. filter; R_{11} is the diode load resistance, and R_{12} is the volume control potentiometer in the grid circuit of the triode a.f. amplifier. The negative d.c. potential developed by the detector is used as bias for V_1 and V_2, the network R_9C_{17} having the function of ironing out a.f. modulation frequencies from this source of bias. The triode functions as an RC-coupled amplifier and is provided with the usual automatic biasing.

The output stage, situated between CD and DE, is simple. The speech coil of the loudspeaker is connected via the usual matching transformer T_3 to the anode circuit of the output tetrode, and $R_{19}C_{23}$ connected between the anode and earth is the tone control circuit. R_{19} is variable, so you can vary the degree of "top cut" in the reproduction. The moving coil loudspeaker has an energised magnet.

Power Supply

The small section of the receiver to the right of the line DE is known as the mains unit, and its purpose is to provide h.t., l.t., and current for energising the loudspeaker. The manner in which these are obtained is as follows. The a.c. mains are connected, via the on-off switch S, to the primary of the transformer T_4, which has three secondary windings. One of these provides a.c. for the heaters of the valves V_1 to V_4. A second winding provides power for the single rectifying valve V_5 in the mains unit. The third winding is centre-tapped, the ends being connected to the anodes of the double-diode V_5.

Current can flow only in one direction in a valve, from anode to cathode, therefore the cathode of this valve becomes effectively the positive terminal of the h.t. supply. It is a peculiar supply, for it gives pulsating current. Before it can be used in a receiver, this current must be smoothed. This is achieved by passing the pulsating current through an inductor — the field winding of the loudspeaker is generally used —to obtain a measure of smoothing. By

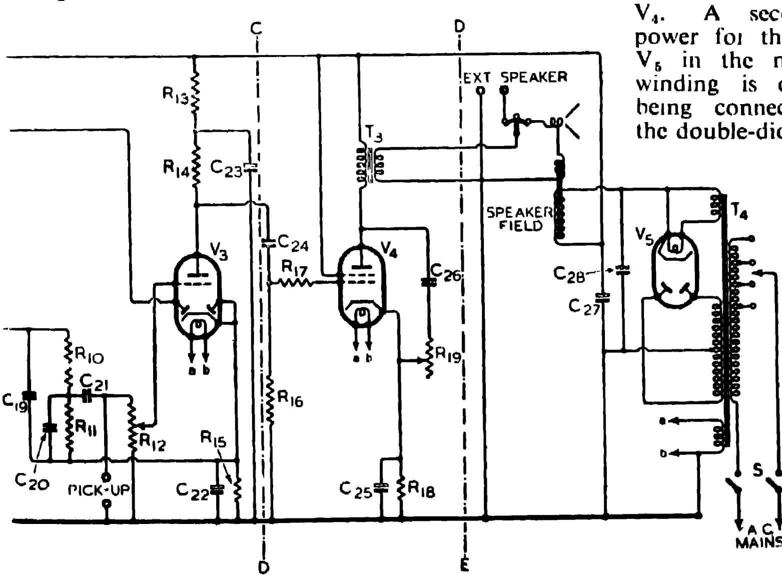


Fig. 24 (continued). Between B C and C D is the detector stage. In V3 are included a diode detector and a triode A.F. amplifier. The output stage between lines C D and D E includes a tetrode V4 and a tone control, R19 C26.

adding the large capacitors C_{27} and C_{28} even more smoothing is obtained, for these will charge up on voltage peaks and discharge on troughs, so exerting a powerful levelling effect.

Even this does not eliminate the last traces of ripple from the h.t. supply, and a slight hum is audible in the loudspeaker as a consequence. These final traces can be eliminated by connecting in series with the speech coil a small winding which injects enough of the ripple from the smoothing inductor to cancel that present.

Performance of the Receiver

The amplification of the receiver is very considerable, sufficient to allow almost any worth-while signal to be well received. But mere sensitivity by itself is useless. Selectivity sufficient to enable the wanted signal to be obtained free from interference by stations on neighbouring frequencies is also a necessity, and in this respect the superhet type of receiver is outstanding. The receiver just described has an effective band-width of less than 9 kc/s. As the frequency separation of the stations on the long and medium wavebands is 9 kc/s, this set is easily capable of separating them.

Because of the high gain of the receiver when tuned to a strong signal it supplies a very large signal to the diode detector. One result of this is that the detector delivers a corresponding high negative voltage to the a.g.c. line, so biasing back V_1 and V_2 and reducing their amplification. Equilibrium finally results with V_1 and V_2 heavily biased back. If a weak station is tuned in, the bias developed by V_3 is small and V_1 and V_2 amplify considerably.

The result of all this is that the receiver tends to give approximately equal audio-frequency output no matter what the signal strength applied between the aerial-earth terminals, i.e. all stations are received at approximately the same output. Also—and this is the main purpose of a.g.c.—should the signal strength of a station vary for any reason at all (due, say, to changes in atmospheric conditions, or even by removal of the aerial lead) the amplification of the a.g.c. controlled valves will change so as to keep the audio output substantially the same. To some extent therefore the set can combat that bugbear of short- and medium-wave reception, fading. But it cannot eliminate the distortion that often accompanies fading.

Portable Superhet.

The circuit diagram at Fig. 25 represents a modern 4-valve "all-dry" portable battery superhet, i.e. it uses valves with 1·4 volt filaments energised from dry cells. The circuit uses a frame aerial, a winding wound on the outside or back of the cabinet.

A frame aerial can be regarded as a tuning coil of dimensions large enough for it to be capable of intercepting radio waves and producing substantial r.f. voltages across its ends. One advantage is that it is markedly directional, and so can be used to eliminate interfering signals if these are not arriving from the same direction as the wanted signal.

Ferrite-rod Aerial

An alternative sometimes preferred to the frame aerial is the ferrite-rod aerial. This consists of a rod of magnetic material, about 8 inches in length, carrying medium- and long-wave coils on it. These coils are tuned by a section of the tuning capacitor and with it constitute the first tuned circuit of the receiver. These rods are horizontally mounted inside the cabinet and yield results fully comparable to, if not better than, those of a frame aerial.

The action of the heptode frequency changer is more or less obvious from the symbol which represents it. The first two grids, those nearest the filament, behave as control grid and anode of a triode oscillator. As the effects of these two electrodes on the electron stream of the valve are mutually destructive, their potentials being 180° out of phase, the anode is usually made as small as possible so that the grid exerts most effect. The rest of the valve behaves as

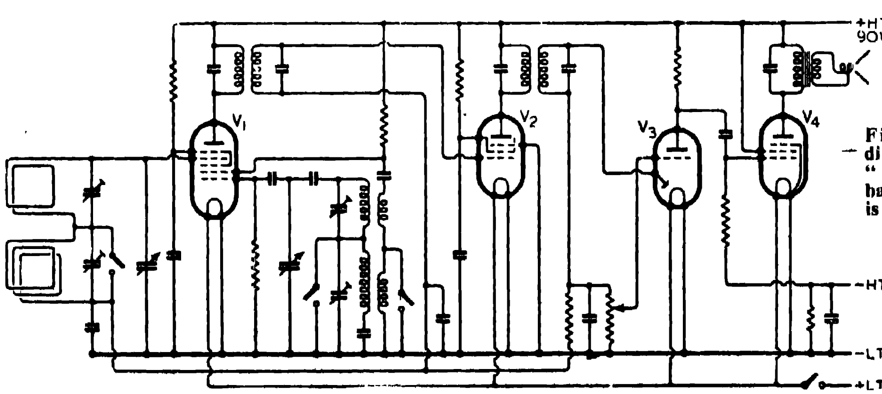


Fig. 25. Circuit diagram of a 4-valve "all-dry" portable battery superhet. V_1 is a heptode frequency changer.

the left-hand side of the triode heptode already discussed. The circuit diagram at Fig. 25 should now be quite clear. To make the set truly portable, both l.t. and h.t. are supplied from a single block of cells, and as the 1·4 volt valves are of very small dimensions, this circuit lends itself admirably to the construction of receivers of very small overall size, yet with a very useful performance.

Universal Receivers

One way in which a.c. mains receivers have been made more compact (and cheaper) is by the omission of the mains transformer, which is a bulky and expensive component. To avoid the necessity for the transformer the receiver uses indirectly-heated valves, with heaters designed to be operated in series. Such a series chain might require a total voltage of, say, 100 volts at 0·2 amps, and it can be operated directly from the mains, provided a suitable dropping resistor is included in the chain to ensure the correct current. If the mains voltage is 230, 130 volts must be developed across the dropping resistor, and since the current is 0·2 amps the resistance must be 130/0·2 = 650 ohms ; the resistor must be capable of dissipating 130 × 0·2 = 26 watts, and it is usually wire-wound.

The h.t. supply for a receiver of this transformerless type can be obtained by rectifying the mains, using a half-wave rectifying valve. These receivers have the advantage that they will operate on d.c. or a.c. mains, and for this reason are called *universal*. When such a receiver is used on d.c. mains the rectifier is not needed for rectification, but it nevertheless performs a useful function ; if the mains voltage is applied to the receiver in the wrong sense, i.e. with the negative pole connected to the rectifier anode, the rectifier will not conduct, and no voltage appears across the smoothing capacitors. These capacitors are usually of the electrolytic, i.e. polarised, type, and they can be damaged by the application of a large voltage of the wrong polarity. Although a universal receiver will not perform when connected the wrong way round to a d.c. supply, it is very easy to achieve such a connection by accident, and the rectifier is necessary to safeguard the smoothing capacitors.

All-dry Types

A disadvantage of universal receivers is that the chassis is generally connected to one side of the mains supply. There is thus a possibility that shocks may be received if the chassis or anything in contact with it (such as the grub screws of control knobs) is touched, and the receivers must be so constructed that such contact is impossible. One side of the main is usually earthed and it is inadvisable to earth the chassis of a universal receiver, because it is possible in this way to short-circuit the mains supply.

Some universal receivers will operate from dry cell l.t. and h.t. batteries as well as from a.c. and d.c. mains. These are, basically, all-dry types using 1·4-volt valves in a circuit similar to that shown in Fig. 25, but they include a half-wave mains rectifier and smoothing equipment which supplies h.t. and l.t. when the receiver is mains-operated. The 1·4-volt valves must be operated from a d.c. supply, to avoid hum, and are thus fed from the rectifier output.

LESSON 10

Frequency Modulation Receivers

The introduction of a frequency-modulation broadcasting service in 1955 was a result of the deterioration of reception conditions in the medium- and long-wave bands, due chiefly to the action of the ionosphere (a charged region of the atmosphere surrounding the earth). This region acts as a mirror for radio waves, reflecting downwards signals arriving from a transmitter. Because of this reflection, a signal from a transmitter can be received at a considerable distance beyond the horizon, and it is by means of this action that long-distance radio communication is achieved.

In the medium- and long-wave broadcasting bands it is largely responsible for mutual interference between waves from transmitters which are remote geographically and are operating on or about the same frequency. The interference usually takes the form of whistles and unintelligible interference (" monkey chatter "). With the increasing number of transmitters, and the higher powers used, reception conditions steadily deteriorated.

Interference

One way out of the difficulty was to use carrier frequencies in the v.h.f. band—the band of frequencies between 30 and 300 Mc/s. For signals in this band (and at higher frequencies) the ionosphere ceases to act as a mirror, and the area served by a v.h.f. transmitter is bounded by the horizon. The B.B.C. television signals in Band 1 (40–70 Mc/s) are radiated in this frequency band, and viewers are aware that while there is negligible interference from other transmitters, there is very considerable interference from motor-car ignition systems, electric motors, etc. Thus the

establishment of a sound broadcasting service in the v.h.f. band might seem to be the exchange of one form of interference for another. This might be so if amplitude modulation were to be used, but the level of interference in a v.h.f. receiver can be greatly reduced by the use of frequency modulation.

Frequency Deviation

As explained in Lesson 3, a system of frequency modulation maintains the carrier amplitude constant whilst varying the frequency, and the effect of ignition and similar forms of interference in such a system is very much less than in a comparable amplitude modulation system. The sidebands of a frequency-modulated signal occupy a much greater bandwidth than those of an amplitude-modulated signal. For this reason, frequency modulation cannot be used at lower carrier frequencies, where the frequency band allocated to a transmitter is only sufficient to accommodate the amplitude modulation sidebands. But in the v.h.f. band, the frequency band allocated to a transmitter can be greatly increased and frequency modulation used.

The maximum frequency swing is, for broadcast purposes, usually limited to 75 kc/s; this limit is called the *frequency deviation*. The sidebands spread over a region slightly greater than twice this value, some 180 kc/s approximately. This may be compared with the upper limit usually adopted for a medium-wave transmitter of 20 kc/s.

Variations of Signal Strength

V.h.f. f.m. sound transmissions for Great Britain are radiated in Band II, 87·5–100 Mc/s. Within this band channels at 200 kc/s intervals are allocated. Because of the restricted range of v.h.f. transmissions, any one channel may be shared by a number of stations, provided these are spaced geographically to avoid overlap of the areas served. Within the "service area" of a transmitter, there may be marked variations of signal strength at a given place. These variations may be due to the shadowing effect of obstacles between the transmitter and receiver, or to reflections from metallic objects such as gasholders. The effects have nothing to do with frequency modulation, but occur because of the high carrier frequencies used. For still higher frequencies, e.g. Band III, the effects may be even worse.

The type of aerial for reception of v.h.f. transmissions in this band is similar to that used for television reception, with the important difference that the aerial for the former is not vertical but horizontal. As for television aerials, H and X types can be used where the received signal is weak.

A frequency-modulation receiver differs essentially, in two respects, from those described earlier. First, the detector is more complex; second, it requires a wider bandwidth throughout to accommodate the sidebands of the signal. The amplitude of the signal does not vary with modulation, and a detector of the type described earlier, which responds only to the variations of signal amplitude, would give a constant output. Practical forms of f.m. detectors are discussed later.

Because of the wide bandwidth required, it might be thought that the t.r.f. form of receiver could be used with advantage, the chief virtue of the superhet being its high selectivity; but it cannot. First, the gain obtainable from a valve amplifier at very high frequencies is low, of the order of 10 to 20. With such gains, a very large number of stages would be needed in a v.h.f. t.r.f. receiver. Second, whilst the bandwidth is considerable, judged by medium- and long-wave standards, it is only a small fraction of a v.h.f. carrier frequency. In discussing selectivity, it is the ratio of bandwidth to carrier frequency which is important: thus a t.r.f. receiver is unsuitable for a v.h.f. f.m. reception, and a superhet must be used.

Low Stage Gains

The intermediate frequency of an f.m. superhet receiver must be considerably higher than the 465 kc/s of the normal a.m. receiver; commonly used values lie in the range 8–20 Mc/s. The commonest value is 10·7 Mc/s, and subsequently this value will be assumed.

The general form of an f.m. receiver is similar to that of an a.m. superhet receiver, indicated in the block diagram, Fig. 23. But there are more stages in the f.m. receiver than a similar a.m. receiver, because of the low stage gains. It might seem that some economy could be achieved by the omission of the r.f. stage, because its gain is usually low, certainly less than that obtainable from an i.f. stage. But such a stage is necessary, for two reasons.

Receiver Noise

First, receiver noise is a serious problem at v.h.f. Noise generated within the valves of the receiver is due to the irregular movement of the electrons through the valve, and its effect is most serious where the signal is smallest, i.e. in the first stage of the receiver. The noise of a frequency-changer is greater than that of an r.f amplifier, and so the ratio of signal to noise can be improved by the use of an r.f. amplifier.

Second, the r.f. stage helps to suppress radiation from the oscillator of the frequency changer. At v.h.f. frequencies it is difficult to prevent some of the output from the oscillator from reaching the aerial, where it can be radiated to interfere with other receivers near by. By interposing an r.f. stage between the aerial and the frequency changer, the effect can be reduced.

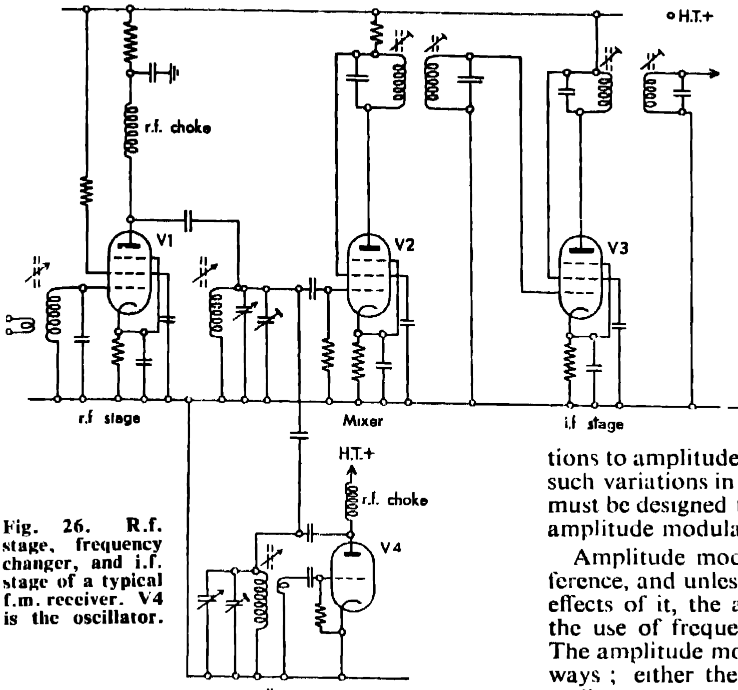


Fig. 26. R.f. stage, frequency changer, and i.f. stage of a typical f.m. receiver. V4 is the oscillator.

The r.f. stage is usually a pentode, one of the miniature types for use at these frequencies. The aerial input coil has very poor selectivity, and because of the relatively small band of frequencies to be received, this circuit is not usually tuned by a section of the tuning capacitor but is permanently tuned, as shown in Fig. 26, to a frequency near the middle of the band.

The frequency changer shown in Fig. 26 uses a separate oscillator; a portion of the output from the oscillator is fed to the grid of the mixer valve V_2 via a small capacitor. The mixer valve is biased back towards anode current cut-off, and the amplitude of the oscillating voltage at the mixer grid is commonly about 3 volts. The intermediate frequency output from the mixer is selected by the tuned transformer in the anode circuit, and fed to the first stage of the i.f. amplifier. This type of frequency changer has generally a higher gain than the types employed in the a.m. receivers described previously. But the latter types have the advantage of requiring only one valve, where the other type has two.

A typical i.f. stage of an f.m. receiver is shown in Fig. 26. It has double tuned transformers, and is generally very similar to the types described previously. The tuning capacitors are commonly between 20 and 50 pico-farads (pf) in value, and the stage gain is of the order of 50–100.

F.M. Detectors

The normal type of diode detector cannot be used directly as an f.m. detector, because the signal amplitude is constant. In fact, there is no device which responds directly to changes of frequency of a signal, and an f.m. detector has two parts, one to convert the signal frequency variations to amplitude variations, the other to detect such variations in the ordinary way. The circuit must be designed to eliminate any output due to amplitude modulation of the incoming signal.

Amplitude modulation may be due to interference, and unless steps are taken to reduce the effects of it, the advantages to be gained from the use of frequency modulation may be lost. The amplitude modulation can be in one of two ways; either the detector can be preceded by a limiter stage which eliminates amplitude modulation, or the detector can itself be made insensitive to amplitude modulation.

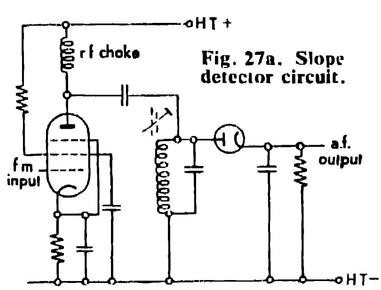


Fig. 27a. Slope detector circuit.

The simplest form of frequency modulation detector is shown in Fig. 27a; it makes use of the shape of the "skirt" of the selectivity curve of a tuned circuit. If the carrier frequency is set to some point on the skirt where the curve is nearly straight, as shown at Fig. 27b, the variations in frequency of the input produce corresponding variations in amplitude of the output as shown; the amplitude-modulated output signal can then be detected in the ordinary way. This type of detector is called the "slope" detector, and it has two main disadvantages. The output is small, and it gives high distortion, because the skirt of the selectivity characteristic is not truly straight. Such detectors have sometimes been used in less expensive f.m. receivers.

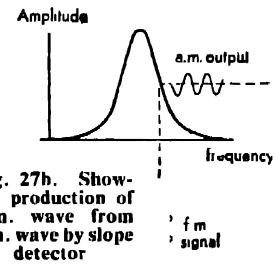


Fig. 27b. Showing production of a.m. wave from f.m. wave by slope detector

LESSON 11

The Theory of Television

THE BBC television service, the world's first to transmit regular programmes, was inaugurated in November 1936. It was closed down in 1939 because of the Second World War, and was not re-opened until 1946, since when expansion has been rapid. Before the war there was only one transmitter, situated at Alexandra Palace in North London. Now a complete network of high-power, medium-power, and low-power transmitters radiates a television programme to virtually the whole of Great Britain. The transmitters in this, the first of the BBC's television networks, have carrier frequencies in Band I, 40–70 Mc/s.

The provision of alternative television programmes by the BBC and the Independent Television Authority (ITA) necessitated further networks of transmitters, with carrier frequencies in Band III, 174–216 Mc/s. Still higher carrier frequencies, in Band IV, 360–400 Mc/s, were envisaged for colour television services.

Photo-electric Scanner

The first step in televising a scene is the production of an optical image of it. This image is, in effect, examined by a photo-electric scanning device which moves over it in a series of straight lines arranged in a pattern similar to that shown in Fig. 31. During the examination the device moves from the left-hand side to the right-hand side (shown by the solid lines in the diagram), then returns very rapidly to the left-hand side (dotted lines) to perform the next line, which is immediately underneath the previous one.

There is no examination of the image during the right-to-left movements, which are called *flyback* strokes to distinguish them from the left-to-right *working* strokes. This process is called *scanning*, and it continues until the entire scene has been scanned by a succession of lines, which total 405 in the British television system. After the completion of the bottom line, the scanning device returns to the top of the image to begin another scanning pattern The movements of the device over the image are similar to those of the human eye in reading a printed page. It produces a voltage proportional at any instant to the brightness of that part of the image on which it happens to be, the voltage rising when bright parts of the image are scanned, falling when darker parts are scanned, reaching zero when black parts are scanned.

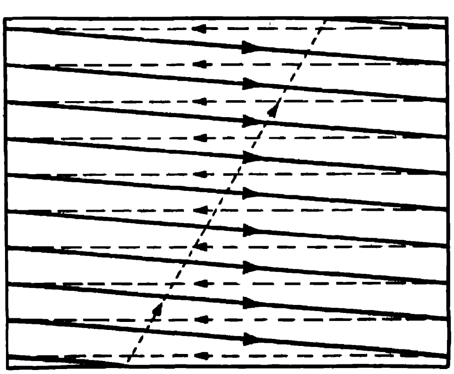


Fig. 31. Frame of 10-line scanning system. Dotted lines are "inactive" or flyback strokes of electron beam.

The output of the scanning device is a voltage which rises and falls in accordance with the light and shade of the image, the variation of this voltage representing the detail of the scene. This voltage corresponds to the audio signal from a microphone in a sound system, and is called a picture signal. It is used, after amplification, to amplitude-modulate the carrier wave at a television transmitter.

Synchronism

The received signal is detected by methods similar to those used for a.m. detection in sound receivers, and is then applied to the input of a cathode ray tube. Here it controls the brightness of the spot of light produced by the electron beam as it strikes the screen of the tube. The electron beam moves over the screen in a pattern of the type illustrated in Fig. 31, and it is essential that this reproducing beam should be precisely in step with the scanning device at the transmitter ; if the transmitting agent is half-way along line 317 at a particular instant, the reproducing beam must also be at the same point of the same line at that instant. This synchronism being maintained, an image of the original scene is built up on the cathode ray tube screen.

Signals additional to the picture signal are transmitted to the receiver to enable this synchronism to be obtained. These are called synchronising or sync signals, and two types are necessary : one to mark the beginning of each line, the other to mark the beginning of each top-to-bottom traverse of the image. These are the *line sync* and *frame sync* signals respectively, and their wave-form is such that it is possible at the receiving end to separate the picture from sync signals and the line sync from the frame sync signals by relatively simple circuits.

A somewhat similar process of dividing images into lines which are then transmitted in sequence

is used in the radio transmission of Press photographs ; here the process is relatively slow, and it takes perhaps 20 minutes to complete a single picture. In television it is essential to obtain a realistic representation of movement in the scene and a number of complete pictures are transmitted in quick succession. In the cinema it is customary to project 24 pictures per second to create this illusion of movement, and in the British television system 25 pictures are transmitted per second. The scanning devices move very rapidly, performing $25 \times 405 = 10{,}125$ scanning lines per second.

Wave-form

The wave-form of the *video* signal, i.e. the combination of picture and sync signals, is illustrated in Fig. 32. The picture signal consists of voltage excursions to one side of the datum voltage B, called the black level, and the sync signals consist of rectangular pulses on the opposite side of the black level. This method of combining picture and sync signals is adopted because it is fairly simple to separate the sync signal ; the method is described in the next lesson. The entire video signal is applied to the input of the reproducing cathode ray tube, but because the datum voltage represents black level, the sync signals correspond to "blacker than black" and have no effect on the screen.

Fig. 32 also illustrates the difference between line and frame sync signals. These are of the same amplitude, but the frame signal is considerably longer in duration than the other ; the difference is more marked than the diagram suggests, the frame signal being approximately 40 times as long as the line sync signal. This difference makes possible a reasonably simple method of separating the two signals.

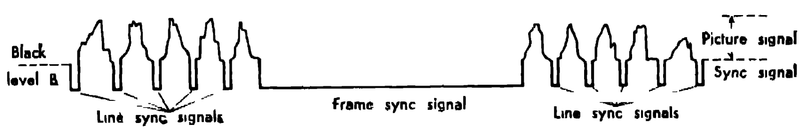


Fig. 32. Simplified television wave-form.

For a number of reasons, the video wave-form is really more complicated than Fig. 32 suggests. For example, the line sync signals are continued throughout the duration of the frame sync signal, but to keep the diagram reasonably simple this is not shown. The frame sync signal has the effect of eliminating the picture signal for the duration of a number of lines, and only 377 of the full complement of 405 lines are seen in a reproduced picture.

Camera Tubes

The scanning device at the transmitting end has the task of producing a voltage proportional to the brightness of the various parts of the image. This process is carried out in the television camera in a tube which has something in common with a cathode ray tube. There are different types of tube, but they have common basic principles.

In essentials, a television camera tube consists of an evacuated glass tube containing an electron gun at one end, and an electrode, called the *target*, in the form of a flat plate at the other end. The electron gun consists of an indirectly-heated cathode to give rise to a stream of electrons, and a number of grids or anodes carrying voltages adjusted so as to focus the electron stream on the target.

The electron beam is deflected by currents in scanning coils clamped to the outside of the tube and it moves over the target in a scanning pattern of the type already described. The image to be scanned is projected through a glass wall of the tube and is focused on the target by an optical lens (as in a photographic camera).

The scanned face of the target is treated with photo-electric material, such as caesium or antimony, which liberates electrons when illuminated by light. The number of electrons lost is proportional to the intensity of the light, and more electrons are lost from target areas in highlights of the image than from areas corresponding to low lights ; no electrons at all are lost from unilluminated areas of the target corresponding to black areas of the image. By loss of electrons the target develops positive charges which are greatest in highlight areas. The way in which these charges are neutralised in order to produce an output voltage differs for the various types of camera tube. There are other differences, too, as pointed out in the following brief descriptions of the types currently in use.

"Emitron" Tube

In the original camera tube ("*Emitron*" or *iconoscope*) the light image and scanning beam fall on the same face of the target, the arrangement being shown in Fig. 33. The target consists of a sheet of mica with photo-electric material on one face, and a conductive coating, called the *signal plate*, on the other. The photo-electric material is deposited not as a continuous coating but in the form of hundreds of thousands of minute "islands" each separated from its neighbour by clear mica, a form of coating called the *mosaic*. When an image falls on the target, each of these islands develops a voltage (by loss of electrons) proportional to the brightness at that point.

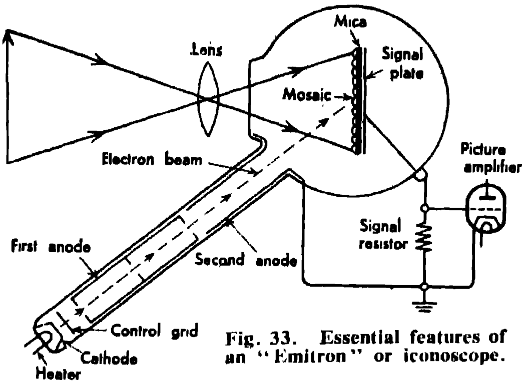


Fig. 33. Essential features of an "Emitron" or iconoscope.

As the scanning beam meets each island during scanning, it discharges it, i.e. returns to it sufficient electrons to make good the deficiency. This transfer of electrons causes a voltage change at the island which is transferred to the signal plate through the capacitance between the two, the mica sheet acting as di-electric. The successive discharge of the islands of the mosaic during scanning produces a succession of pulses at the signal plate which can be applied to the input of the picture amplifier, as shown in the diagram. This camera tube can produce very good pictures but has disadvantages, and it has been replaced by other types, described below.

Super "Emitron" or "Photicon"

Many of the disadvantages of the iconoscope were overcome in its successor, the super "Emitron" or "Photicon" (image-iconoscope), which is still used for studio programmes. This is a smaller tube with greater sensitivity. It differs from the iconoscope in that the light image falls on an electrode called a *photo-cathode*, which is quite separate from the target scanned by the electron beam. The photo-cathode liberates electrons under the stimulus of the light in the optical image, and these are guided towards the target, which they strike with sufficient force to liberate further electrons, called *secondaries*, from the target. Five secondary electrons can be released from the target for each electron received from the photo-cathode, and this gain accounts to some extent for the superior sensitivity of this type of tube. By loss of secondary electrons the target develops voltages on its scanned face, and these are neutralised to produce an output from the signal plate by a process very similar to that which occurs in the iconoscope. The iconoscope and image iconoscope have insufficient sensitivity for use outdoors on a dull day. This lack of gain and the presence of spurious output signals are both due indirectly to the high velocity of the scanning beam.

Orthicon Camera Tube

Immediately after the Second World War research began in Great Britain and in the U.S.A. on the development of camera tubes with low-velocity scanning beams, and two types, the *orthicon* and the *image-orthicon*, are now in regular use.

Apart from the difference in scanning-beam velocity, the orthicon or C.P.S. "Emitron" is basically similar to the iconoscope as shown in Fig. 34. It consists of a cylindrical tube with a target at one end and an electron gun at the other. The target has a mosaic on the face scanned by the electron beam, and a signal plate on the other face. The optical image is projected on to the target in a direction opposite to that of the electron beam. The light must, of course, reach the mosaic to liberate electrons, and the signal plate is transparent, consisting of a very thin layer of tin.

Image-orthicon Tube

As the name suggests, the image-orthicon is basically an orthicon tube but has two separate electrodes—a photo-cathode (on which the light image is focused) and a target (which is scanned by the electron beam). Electrons released by light from the photo-cathode are accelerated towards the target, striking it with considerable velocity and releasing secondary electrons from it. The resulting positive charges on the front face of the target travel through it to the rear face, where they are neutralised by the scanning beam. There is no signal plate associated with the image-orthicon target and the output signal is derived from the scanning beam in an interesting way.

The scanning beam supplies electrons to a particular point of the target in direct proportion to the brightness of that part of the optical image which corresponds to the point in question. A large number of electrons are supplied to highlight regions of the image, none at all to black areas. Scanning-beam electrons which are not supplied to the target return to the anode of the electron gun. The electron beam outgoing from the gun is of constant density, and thus, during the process

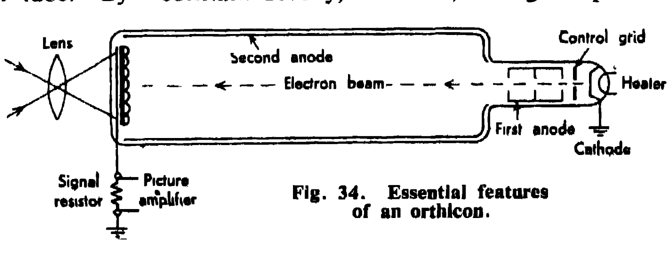


Fig. 34. Essential features of an orthicon.

of scanning an image, the number of electrons returning to the gun is constantly varying, the variations corresponding with the detail of the image. In the image-orthicon tube the return scanning beam is directed, by suitably-placed electrodes carrying carefully-adjusted voltages, into the input of an *electron multiplier*.

In this amplifier, which is built into the camera tube and surrounds the electron gun, the return beam strikes an electrode at considerable velocity and releases secondary electrons, which outnumber the return beam by about 4 : 1. These secondaries are collected and directed, again at great velocity, against a second electrode, where they release an even greater number of secondaries. This process is continued until an amplification of several thousand is obtained, and the tube output is taken by conventional RC-coupling from the final electrode of the electron multiplier.

Because of the gain of the image section and the electron multiplier, the sensitivity of the image orthicon is very high ; indeed, it can be of the same order as that of the human eye. With such a tube it is possible to televise a scene by the light of the moon only.

LESSON 12

Television Receivers

A TELEVISION receiver may contain as many as 20 valves. Also it contains two virtually distinct receivers (one to provide the picture, the other to provide the sound). Modern receivers are generally so designed that they can be tuned to any of the five channels in Band I (40–70 Mc/s), and any of the eight channels in Band III (174-216 Mc/s).

Some have a two-position switch, giving a choice between Band I and Band III, the receiver being adjusted internally, before installation, to the channels appropriate to the area in which it is situated. Other receivers are equipped with a 12-position tuning control which, in conjunction with a fine tuning control, enables all of the channels on Bands I and III to be selected. The word channel, as used here, implies both a vision and a sound transmission, and in British television the sound carrier is always 3·5 Mc/s lower than the associated vision carrier. The receiver is so designed that both carriers are automatically selected together.

The principal functions carried out in a television receiver are indicated in Fig. 35. The vision and sound receivers are usually superheterodynes which, for convenience, have common r.f. amplifier and frequency changer, as shown. The remaining sections of the two receivers—i.f. amplifier, detector, and following amplifiers—are quite separate. The sound detector feeds an a.f. amplifier and a loudspeaker as in broadcast sound receivers, and the vision detector feeds a video amplifier which is connected to the input of the cathode ray tube.

The video amplifier also feeds a stage, called the sync separator, which abstracts the sync signals from the video signals. It also separates the line sync from the frame sync signals and applies these, respectively, to the line and frame time bases. The time bases each contain an oscillator and amplifier, and each feeds scanning coils clamped to the neck of the cathode ray tube, the line time base controlling horizontal movement of the beam and the frame time base vertical movement. In addition, the television receiver contains mains rectifying and smoothing equipment to supply all these sections with h.t. current, and a generator of extra h.t. (up to 14,000 volts) for the final anode of the cathode ray tube.

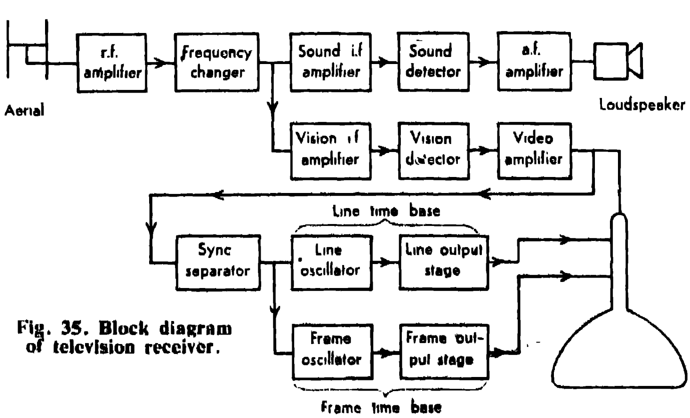


Fig. 35. Block diagram of television receiver.

A commonly used value of intermediate frequency is 34·65 Mc/s, and the oscillator frequency is usually above the signal frequency. Thus, if the receiver is tuned to 45 Mc/s (Band I), the oscillator is at 79·65 Mc/s. The accompany sound is on 41·5 Mc/s, and the sound intermediate frequency is 79·65 − 41·5 = 38·15 Mc/s. If the receiver is switched to 190 Mc/s (Band III), the oscillator frequency is changed to 190 + 34·65 = 224·65 Mc/s. The sound transmission is on 186·5 Mc/s, which differs from the oscillator frequency by 38·15 Mc/s and is automatically selected by the

sound i.f. amplifier. In a short lesson it is not possible to give a detailed description of the circui s used in television receivers, but the basic principles can be indicated.

Television Aerials

The aerials used with television receivers are mostly designed to operate on one transmission only. For example, a television aerial for the Band I London transmission is required to operate at a vision carrier of 45 Mc/s and a sound carrier of 41·5 Mc/s, and it can be designed to give maximum response to frequencies of this order. It is not possible to adopt the same principle in the design of broadcast aerials, because of the wide frequency range at which they are required to operate; the medium waveband, for example, covers a frequency range of 3 : 1.

A television aerial commonly consists of a vertical rod approximately half a wavelength long, and cut at the centre to feed the two conductors of a feeder which conveys the aerial output to the receiver. The aerial is sometimes fitted with a reflector of approximately the same length and mounted parallel to the aerial at a short distance from it. The reflector can be used for two purposes: placed behind the aerial it doubles the signal strength at the receiver; placed between the aerial and a source of interfering signals (e.g. motor cars) it can much reduce the interference (excepting when the wanted and unwanted signals originate from approximately the same direction). The combination of aerial, reflector, and support gives the H-shape shown in Fig. 36. There are alternative arrangements of X-form, and combinations of Band I and Band III aerials.

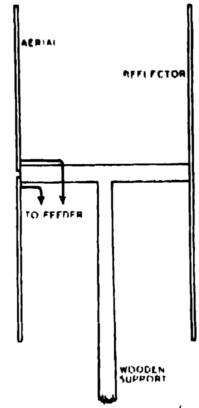
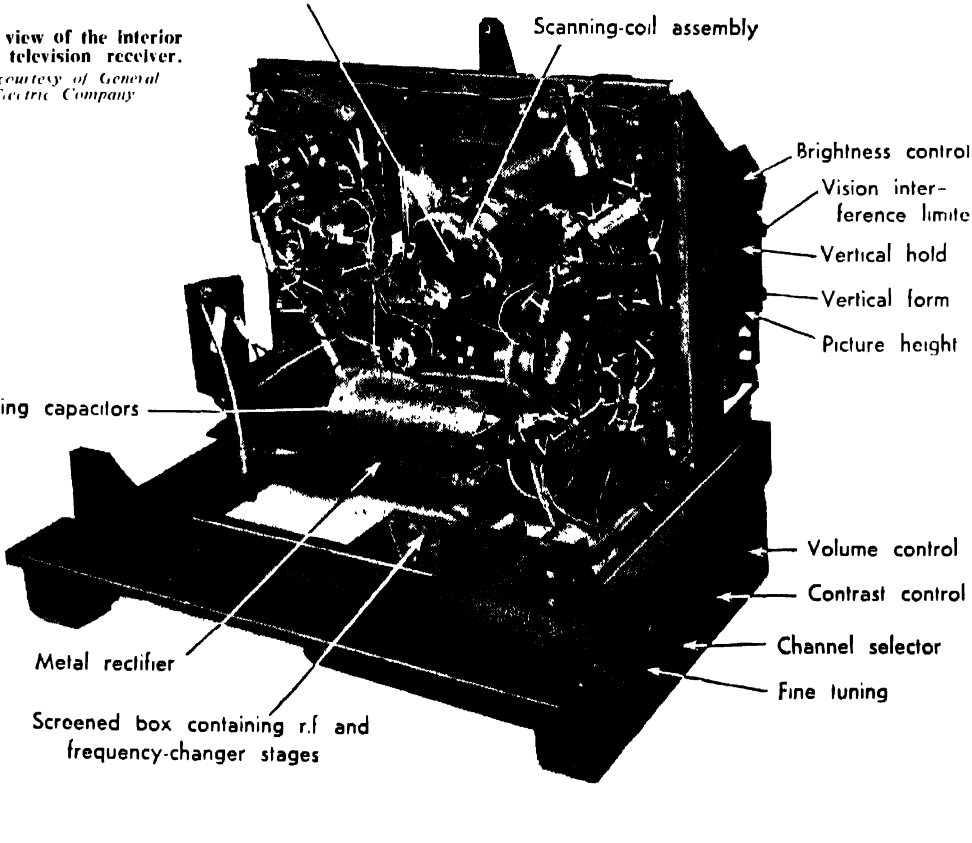


Fig. 36. One type of aerial used with television receiver

The circuits used in the r.f., frequency changer and i.f. sections of a television receiver are basically similar to those described for sound receivers, although there are differences. For example, it is difficult to obtain good amplification at frequencies as high as 200 Mc/s as



Front view of the interior of a television receiver.
By courtesy of General Electric Company

required for Band III reception. Conventional pentodes are not satisfactory at such frequencies, and extensive use is made of a circuit using two triode valves and called the *cascode* circuit.

Circuit Details

Frequency changers commonly consist of two valves, one operating as oscillator, the other as mixer, and the link between the two is sometimes a very small capacitor from the grid of one valve to the other. This circuit is called an *additive* frequency-changer, and it has the advantage over *multiplicative* frequency changers (such as the triode-hexode) in that it is more suitable for use with very weak signals.

The i.f. amplifier may include two or three stages. And the i.f. transformers are similar in principle to those of a broadcast sound receiver, except that they are designed to operate at, say, 34·65 Mc/s instead of 465 kc/s, and to accept a bandwidth of 3 Mc/s compared with the 10 kc/s of a sound receiver.

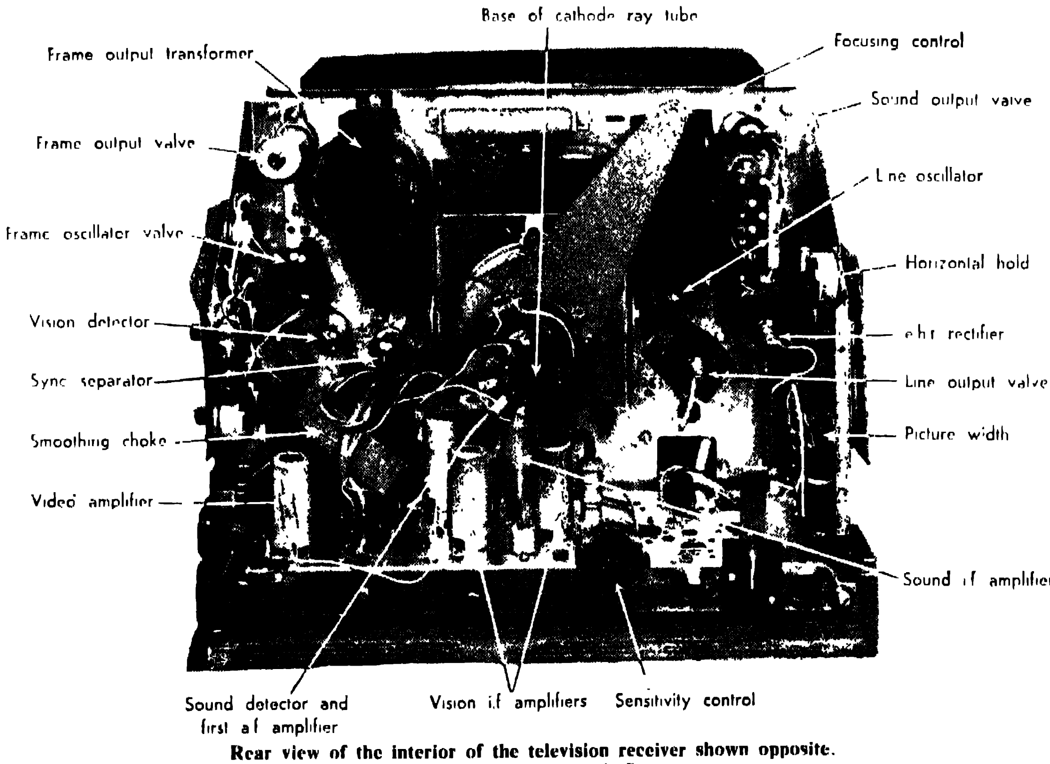
The grid bias of the r.f. stage and usually the first i.f. stage can be adjusted by a potentiometer which thus controls the gain of the vision receiver. In a broadcast receiver such a control would determine the volume of the sound output from the loudspeaker ; but in a television receiver it determines the brightness of the highlights relative to that of the lowlights—it controls the *contrast* of the reproduced picture and is usually labelled as a contrast control.

The gains of the second and third i.f. amplifying stages may be controlled by an a.g.c. bias obtained from a later stage of the receiver. In this way the brightness and contrast of the picture can be kept reasonably constant in spite of any variations in the strength of the received signal. Variations may occur at some distance from the transmitter as a result of natural causes, and anywhere as a result of reflections from aircraft. The latter cause very rapid fluctuations in signal strength, called *flutter*. The incorporation of a.g.c. in a television receiver is not so simple as in a sound receiver, and very ingenious circuits have been developed to overcome the difficulty.

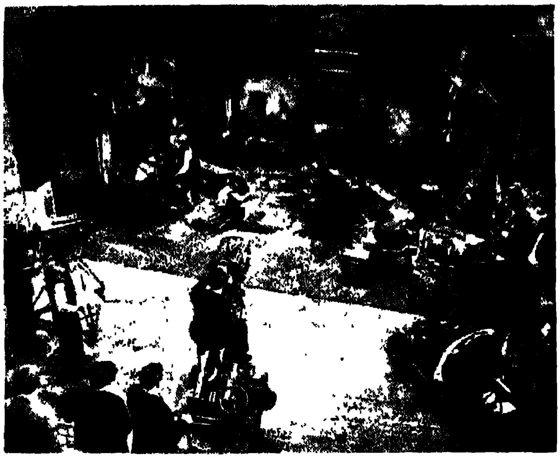
Interference Reduced

The vision detector is usually a diode, and is generally associated with a second diode embodied in a circuit designed to reduce the effects of interfering signals from car ignition systems, electric vacuum cleaners, etc. These signals cause white flashes on the screen.

The video amplifier is usually a simple RC-coupled amplifier with a response up to 3 Mc/s,



Rear view of the interior of the television receiver shown opposite.
By courtesy of General Electric Company



Above. Televising "The Jolly Beggars" at the B.B.C. studios in Edinburgh.

Top right. Televising a scene from "The Deep Blue Sea."

Right. General view of the B.B.C. Lime Grove studios.

Below. Continuity announcer at Broadcasting House, London. The continuity operator is seen through the glass panel.

Bottom right. General view of the Bush House control room, London, showing the programme switching position at the far end.

Photos, B.B.C.

B.B.C. TELEVISION CAMERAS IN ACTION, AND CONTROL AND CONTINUITY OPERATORS AT WORK

and sometimes a small inductor is included in series with the anode resistor to improve the response at the upper end of the band. Commonly, the anode of the video amplifier is directly connected to the cathode of the cathode ray tube. The control grid of the tube is connected to the slider of a potentiometer connected across the h.t. supply ; this control alters the bias of the tube, varying the anode current and the brightness of the picture.

The anode of the video stage also feeds the sync separator, applying to it a signal of possibly 40 volts amplitude and which is inverted with respect to the picture shown in Fig. 32 : the sync signals are positive-going, the picture signal is negative-going. The sync separator is an RC-coupled amplifier which is grossly overloaded by such a large signal input. By appropriate choice of bias conditions in the sync separator it is arranged that the valve is cut off by the negative-going picture signal and takes current only on the receipt of the positive-going sync signals The anode circuit of the sync separator therefore contains line and frame sync signals only.

The output of the sync separator is applied to the time bases through circuits incorporating RC networks and diodes which are designed to apply the correct sync signal to each time base. At the time bases these signals have the effect of initiating each forward stroke ; they compel the oscillators to run at the correct frequency, and ensure that the time bases in all receivers start their forward strokes at the same instant.

Time Bases

Each time base consists fundamentally of an oscillator stage followed by an amplifying stage. The oscillator does not produce a sine-wave output as does the oscillator in a frequency changer ; it develops a signal so shaped that when it is passed through the deflecting coils clamped to the neck of the cathode ray tube it causes the beam to move at constant speed across (or down) the screen with a rapid flyback

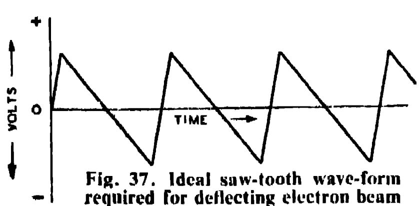


Fig. 37. Ideal saw-tooth wave-form required for deflecting electron beam in television transmitting and receiving tubes.

at the end of each working stroke. The shape of the wave-form required to produce such motion is similar to that of a sawtooth, consisting of a slow fall and a rapid rise, as in Fig. 37.

The time base oscillators will operate even in the absence of sync signals, and the electron beam in the cathode ray tube is subjected to deflecting forces even when there is no input to the receiver. Thus the screen of the tube will light up when the brightness control is advanced, even when the aerial is disconnected.

TYPES OF CATHODE RAY TUBE manufactured by Mullard Electronics Ltd. The three large ones with circular screens are used in radar equipment for tracking, and on plan position indicators. The rectangular screen is of the type built into television receivers. The small circular screen is a projection television tube.

Each time base has a control which adjusts the frequency of oscillation. The control is necessary because an oscillator can be synchronised properly only when its frequency is slightly below that of the sync signals. Synchronisation cannot be obtained if the oscillator frequency is too high or too low, and there is a limited range of adjustment of the frequency control within which synchronisation is obtainable and normal receiver operation is possible. The frequency controls are generally labelled *line hold* and *frame hold*. Adjustment of the frame hold control is often critical, particularly if the receiver has a weak input signal.

Cathode Ray Tube

The cathode ray tube, though the most expensive component in the receiver, is probably the simplest. It consists of an evacuated glass tube with an electron gun at one end and a screen at the other. The screen is a coating of a material which glows when struck by an electron beam. The electron gun consists of an indirectly-heated cathode, a control grid, and an anode which requires up to perhaps 14,000 volts.

Some electron guns contain an additional anode requiring a lower value of h.t., perhaps 300 volts. The beam is focused on the screen

by a magnetic field along the axis of the gun ; in modern receivers this is produced by a permanent magnet in the shape of a ring which surrounds the neck of the tube. A wheel or handle can be moved to adjust the strength of the field and obtain a crisp picture.

The very high voltage required by the tube could be obtained from a secondary winding on a mains transformer, as was done in early television receivers. In the manufacturers' struggle to reduce costs and to produce receivers which would operate from a.c. or d.c. mains, the mains transformer was abandoned and the h.t. supply had to be obtained from some other source. The most common method is to obtain the required voltage from the output stage of the line time base. When the sawtooth current in this stage changes rapidly to perform the flyback stroke, a high alternating voltage is generated, and this can be rectified to produce the required very high voltage.

Sound Receiver

The sound receiver has usually one or two i.f. stages, and these are not designed, as may at first be thought, to have a passband of 10 kc/s width. Such a narrow passband would restrict the highest audio frequencies that can be reproduced, to the unnecessarily low value of 5000 c/s ; and it would require the oscillator to hold its frequency (possibly 200 Mc/s or more for Band III reception) within a few kc/s. This represents a very high standard of stability, which would be difficult to maintain in the mass production of receivers. It is easier to give the sound i.f. amplifier a passband of 50 kc/s or more, which will allow for slight wandering of the oscillator frequency, and will give better audio quality.

The detector is usually a diode, and is associated with another interference-limiting diode, as in the vision detector stage. The audio amplifier following the detector is quite simple—it is often a single valve driving the loudspeaker, and contains a volume control which, together with those for channel selection, contrast, brightness, line and frame hold, form the principal controls of a television receiver.

The mains rectifying equipment of television receivers usually comprises a half-wave rectifier (often a metal one, but sometimes a valve), a smoothing choke, and a double electrolytic capacitor. The current required is large—perhaps 200 mA or more—because there are two receivers and two time bases to be supplied.

Method of Construction

The photographs in pages 2016 and 2017 illustrate the method of construction adopted in one receiver. All the valves and the principal components are labelled, but the loudspeaker is normally mounted on the cabinet and is not shown in the photographs. The majority of the components are mounted on a vertical panel, and these include the cathode ray tube, its neck passing through a hole. The tube is not shown in the front view of the panel, because it would obscure some of the components.

In addition to the vertical panel there is a subsidiary horizontal panel which carries the i.f. amplifiers, the video amplifier, and a valve acting as combined sound detector and first a.f. amplifier. Another item is a screened box containing the r.f. and frequency-changer components. This has a double-triode r.f. amplifier, and a triode-pentode combined oscillator and mixer. Projecting from this box is a combined channel selector and fine tuning control.

BOOK LIST

Elementary. *Basic Radio*, C. L. Boltz (Nelson) ; *Foundations of Wireless*, M. G. Scroggie (Iliffe) ; *Amateur Radio Handbook*, ed. J. Clarricoats (Radio Society of Great Britain) ; *Admiralty Handbook*, Admiralty (H.M.S.O.).

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Television. *Principles of Television Engineering*, S W. Amos and D. C. Birkinshaw (Iliffe) ; *Television Receiving Equipment*, W. T. Cocking (Iliffe).

Frequency Modulation. *Frequency Modulation Engineering*, G. G. Johnstone and. C. E. Tibbs (Chapman & Hall).

ZOOLOGY

THIS *Course consists of a survey of the animal kingdom, with mention of the habits and structure of certain forms. Further information as to the functioning of the body in the vertebrates, to which man belongs, is given in the Course on* PHYSIOLOGY *in Vol. 2. Reference should also be made to* BIOLOGY *in Vol. 1, and to* GEOLOGY *in this volume.*

31 LESSONS

LESSON 1

Introduction

Zoology is the science concerned with the study of what animals are, what they do, and how they came into being. This study of structure, function, and development is a branch of the more comprehensive science of biology, which deals with all living things and thus comprises botany, the study of plant life, and the sister science of zoology.

Living organisms– by which term is meant animals and plants—possess in common certain characteristics not shared with inanimate objects: they feed, grow, and multiply. Life can be defined as the state or condition of a being which feeds, grows, and reproduces itself.

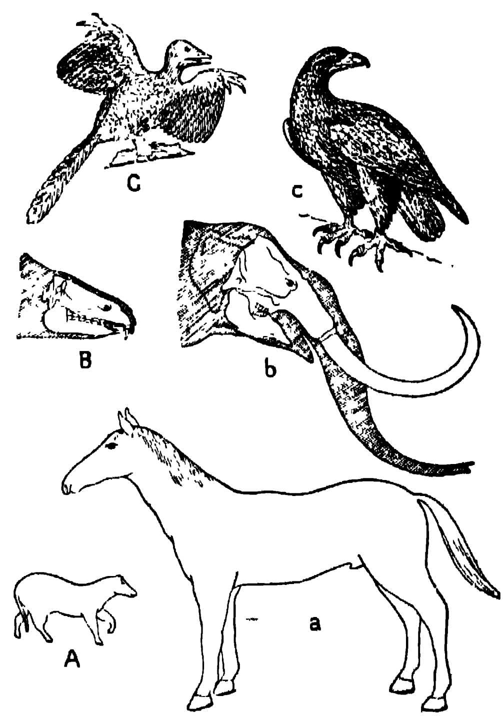
By growth is meant a process very different from that taking place when a snowball is rolled down a hill, or when a crystal is suspended in its mother liquor. Growth of the organism takes place not by a superficial addition of new material, but by the intercalation of new material between the finest particles of the old—what is sometimes termed growth by intussusception. By multiplying or reproduction is meant the formation of new living beings from pre-existing living things. Reproduction may be either sexual, which involves the fusion of elements derived from two individuals, or asexual.

Differences Between Animal and Plant

The student of zoology must first inquire what constitutes the principal difference between an animal and a plant. In practice the distinction is usually obvious; few people would have difficulty in referring a cow or a cabbage to its appropriate kingdom, but there are cases which are not so clear. The basic difference between animals and plants concerns the method by which the organism obtains the supply of energy which is essential for its maintenance, growth, and reproduction. Green plants contain a pigment, chlorophyll, which enables them to capture radiant energy from the sun and to use this energy in building up the complex substances of their bodies (proteins, carbohydrates, and fats) from simpler substances such as nitrogen, carbon dioxide, and water.

Animals possess no chlorophyll, and cannot utilise solar energy directly; instead, they must obtain nutriment in the form of complex substances, which are broken down, during the processes of digestion and respiration, to simpler substances. During this breakdown energy is released, and can then be used for the various needs of the animal, including the building up of its own proteins. Some plants, such as fungi and bacteria, have no chlorophyll, but nevertheless utilise relatively simple substances, exploiting a wide range of energy producing processes. Animals must eat, and may eat plants, or may eat other animals; in either case they depend ultimately on the green plants for their supply of energy.

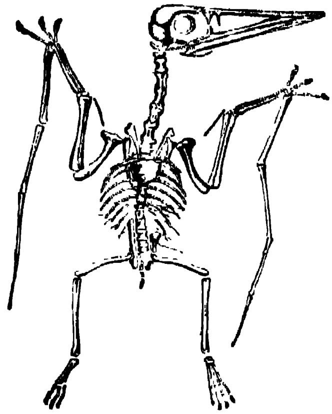
Some obvious animal characteristics result from this necessity to obtain food; all animals are capable of active movement at least at some stage of their lives, and all animals are irritable, in the sense that they respond to stimuli reaching them from the environment. Most animals seek their food actively, though some are sedentary and wait for food to be brought to them in various ways; even these can move their parts actively, which most plants cannot. Plant cells have rigid walls of cellulose; but animal cells do not, which aids motility. In the larger animals, movement involves the possession of muscles, and of a nervous system. Cases in which there is some confusion between animals and plants will become apparent later.



STAGES IN EVOLUTION. A, Early four-toed ancestor of the horse. Its proportionate size is shown by comparison with (a). B, Head and skull of an early ancestor (Moeritherium) of the elephant, whose head and skull are shown in (b). C, The oldest known bird, Archaeopteryx, compared with (c) golden eagle.

By courtesy of Andrew Melrose

The modern outlook on animals has been modified by evolutionary ideas. The theory of evolution by natural selection suggests that those animals which are most suited to their environment are more likely to survive and will produce more descendants than their relatives which are less well adapted, so that the population, and the species as a whole, will in time come to consist only of well-adapted individuals. If the environment alters, the characters of the species will in this way be able to change to fit the new conditions. Any given animal can be looked upon as the embodiment of a number of successful adaptations to the problems of life, some having reference to the preservation of the individual, others to that of the species.



PTERODACTYL. Skeleton of P. spectabilis, a short-tailed flying reptile, precursor of the modern bird.

By courtesy of the Trustees of the British Museum

For instance, modern horses are adapted for life on grassy plains; the teeth are modified for cropping and grinding hard grasses, and the legs long, with single toes and hoofs, well suited for swift running. Elephants are large herbivores: their pillar-like legs are adapted to carry the great weight of the body, and the teeth are modified to provide a large surface for grinding the quantities of herbage such an animal must eat. The trunk is a nose developed as a manipulative organ, compensating for a short neck.

Adaptations

Birds are adapted for aerial flight, the fore-limbs being modified as wings; feathers both keep the body warm and provide the plane surfaces of the wings; the bones are hollow, so as to reduce weight. Aquatic birds have webbed feet; the penguins have lost the power of flight, using the wings as paddles. Some mammals have also become aquatic and have changed their legs to paddles; seals and whales are examples. Mammals which have taken to burrowing usually have short limbs and spade-like claws, as has the mole. Some other mammals, not closely related to the familiar mole, have similar habits and also a similar appearance. Flesh-eating mammals have sharp-edged, shearing teeth.

The ancestors of these animals did not show the various adaptations to the same extent. The earliest horses were smaller and shorter legged than modern horses, had several toes, and teeth that were less efficient grinders. *Moeritherium*, thought to be ancestral to the elephants, probably looked rather like a tapir. The earliest known birds had already developed feathers, but in their other structures were very similar to some contemporary reptiles, having a long tail, and teeth.

Knowledge about the ancestors of animals living to-day is obtained from the study of fossils, the petrified remains of animals buried in sediments which have since been transformed into rocks. Usually, only hard parts such as bones or shells are preserved, though sometimes fortunate preservation allows soft parts to be seen as well. Rocks of various ages are exposed upon the surface of the earth, and, since the sediments were laid down one upon the other, the oldest rocks will be those lying beneath the other ones; the animals whose remains are found in the rocks lived at the time the sediments were being laid down. The series of rock will not be continuous, for at times they will have been exposed by earth movements and weathered away. Modern methods of measuring the radioactivity of certain minerals allows the age of some rocks to be determined, and evidence from the thickness of strata and the types of fossil occurring is used to amplify this data.

Definite Evidence of Evolutionary Change

A series of geological periods is recognized, which is set out in the accompanying table, together with the estimated duration of each period and the time which has lapsed from its beginning to the present day. The times given are only approximate, and are in millions of years. The periods are named sometimes from localities in which rocks of that age are exposed, as the Cambrian in Wales and the Devonian in

TABLE OF GEOLOGICAL PERIODS

Era	Period	Duration in millions of years	Millions of years since beginning
Cainozoic or Cenozoic	Pleistocene	1	1
	Pliocene	11	12
	Miocene	17	29
	Oligocene	11	40
	Eocene	20	60
	Paleocene	15	75
Mesozoic	Cretaceous	60	135
	Jurassic	40	175
	Triassic	35	210
Palaeozoic	Permian	30	240
	Carboniferous	50	290
	Devonian	30	320
	Silurian	30	350
	Ordovician	70	420
	Cambrian	80	500

Devon; sometimes for the type of rock found, as the Carboniferous, containing coal, and the Cretaceous, chalk ; and sometimes for other reasons. For convenience, the periods are grouped into eras: the Palaeozoic, Mesozoic, and Cainozoic (or Cenozoic). Rocks older than five hundred million years do not contain recognizable fossils, partly because the rocks have been altered by pressure and partly because the animals living then were mostly soft-bodied.

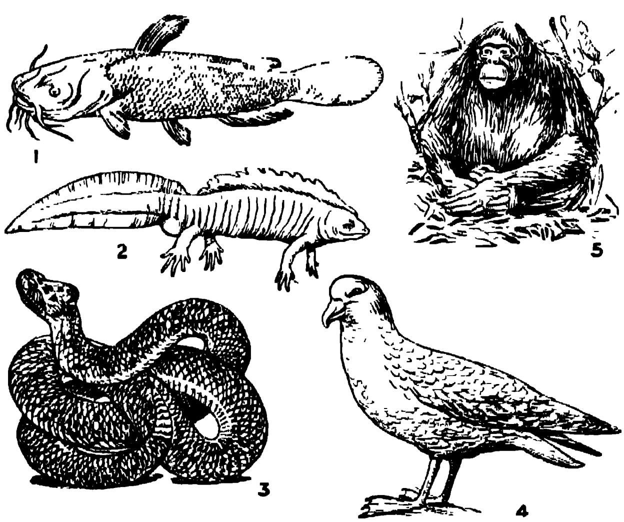
Definite evidence that evolutionary change has occurred is provided by the fact that fossils in ancient rocks are of animals unlike those occurring in higher strata. Particular forms will occur throughout a thickness of rock, but above that they will not be found. The upper layers will contain fossils not occurring below. This indicates that in the habitat in which those sediments were laid down, the first type of animal was in time replaced by the second.

LESSON 2

Zoological Classification

The earth is populated by an enormous number of different kinds of animals, some kinds resembling each other closely, while others are widely distinct. Frogs and toads are sufficiently alike to be confused in the minds of the casual observer, though a jellyfish and an elephant have apparently nothing in common. When due consideration is given to this question of animal resemblances and differences it is found possible to arrange animals in groups according to their similarities. The arrangement must be made carefully with special reference to the features of the structural plan on which the bodies of animals are built, and it requires the co-ordination of several branches of zoology to effect a scientific arrangement.

The comparative study of animal form, or *morphology*, begins with the examination of external characters—divisions of the body, number and position of limbs, relations of mouth, eyes, and ears, and characteristics of the skin—and proceeds to a study of the form and position of the various organs of the body, such as the heart, lungs, and brain. Special study must be given to the minute structure of such organs as revealed by the microscope, and this constitutes the sub-science of *histology*. A study of the function of parts and organs of the body is equally important, as a correlative of morphology, and this forms the basis of *physiology*. Sometimes adult structure alone is an insufficient guide, and real affinities are to be found only in young animals, so involving the study of development, *embryology*. Animals which lead sedentary lives or live as parasites upon or within other animals often fail to reveal their true nature in adult life. *Palaeontology* can also assist the study of classification.



VARIOUS VERTEBRATES. 1, Catfish (Amiurus catus). 2, Warty newt (Triturus cristata). 3, Texas rattlesnake (Crotalus atrox). 4, Petrel (Fulmarus glacialis). 5, Orang Utan (Simia satyrus).

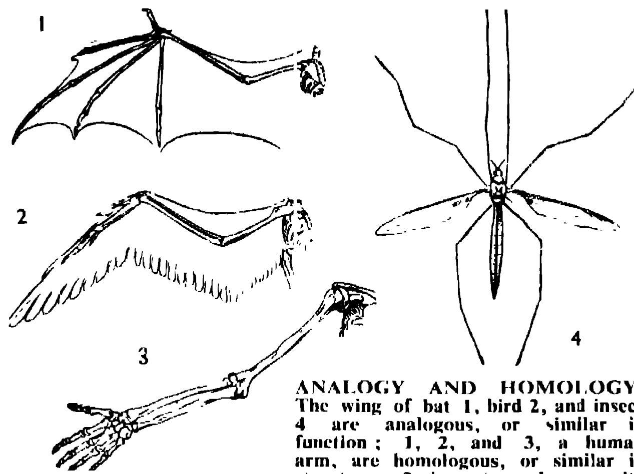
1, 2, and 3, from Shipley & MacBride's "Zoology," by permission of Cambridge University Press

Classification begins with the grouping of individuals into *species*, species into *genera*, genera into *families*, these again into *orders*, *classes*, and *phyla*—divisions of increasing size. The prefix *sub-* indicates an intermediate division between one group and the next. The species is the unit of classification, and includes all animals which are indistinguishable from one another by any constant difference not due to age or sex, and which unite freely with one another to produce fertile offspring. In some instances it is possible artificially to cross members of different species, in which case either no young at all are produced or the offspring are *hybrids* incapable of reproduction. The mule is a familiar example, being the result of a cross between the horse and the ass.

The scheme of classification will be comprehended readily from the following illustration. Many animals which do not bear very close resemblances to one another possess in common a backbone consisting of a number of disks or vertebrae ; the possession of this structure

merits the grouping of such animals into a single phylum, the Vertebrata—or, as it is more correctly called, the Chordata. The different types of animals belonging to the phylum Chordata are further subdivided into smaller groups or *classes*, such as the mammals, birds, reptiles, amphibians, and several classes of fish, each of which has its own set of characteristics. Thus, mammals have a covering of hairs and suckle their young, while birds possess feathers.

The class Mammalia, although presenting uniform features as regards type of body covering and reproductive habit, embraces a number of different animal types, which are segregated in smaller groups or *orders* according to the degree of likeness. The order Carnivora, for instance, includes cats, lions, tigers, dogs, wolves, jackals, and foxes. These animals are obviously more closely related to one another than to hoofed animals such as sheep, deer, antelopes, and pigs, which are placed in the order Artiodactyla. Animals such as rats, mice, and beavers, which lack canine teeth and gnaw their food, belong to the order Rodentia.



ANALOGY AND HOMOLOGY. The wing of bat 1, bird 2, and insect 4 are analogous, or similar in function; 1, 2, and 3, a human arm, are homologous, or similar in structure. 3 is not analogous with 1, 2, and 4, and 4 is not homologous with 1 and 2 and 3.

Examining the characteristics of the Carnivora more closely, we find differences and resemblances suggestive of closer or more distant relationships. Dogs, wolves, foxes, and jackals are more closely similar to one another than any one of these animals is to cats, tigers, lions, and leopards. The two sets of animals must be placed in respective lower groups or families, the Canidae and the Felidae. Similarly, bears must be segregated as the family Ursidae, hyaenas as the Hyaenidae, and civets as the Viverridae. Lions, tigers, and cats show sufficient affinities to merit their being placed together in the genus *Felis*. But the cheetah or hunting leopard, although a member of the cat family, differs from its fellows in having imperfectly retractile claws and in certain peculiarities of dentition; it must be placed in a separate genus, *Cynaelurus*. The final separation into *species* distinguishes between members of the genus *Felis*, so that wild cats, domestic cats, lions, tigers, and leopards are referred to the respective species *sylvestris*, *catus*, *leo*, *tigris*, and *pardus*.

Genus and Species

Linnaeus introduced the system of binomial nomenclature according to which each kind of animal receives two names: the generic name, common to all species of the genus, and the trivial name, peculiar to the particular species, the two together forming the specific name. Both names are usually Latin in form and frequently are the names of persons or places with latinised terminations, and both are written in italics. The generic name is placed first, and, unlike the trivial one, is written with a capital letter. To take familiar examples already mentioned, the domestic cat is called *Felis catus*, the tiger *Felis tigris*, the lion *Felis leo*. Since the common names of animals vary considerably in different countries—and even in different parts of the same country—the scientific nomenclature serves as an Esperanto of animal names, whereby the zoologist can refer to a form and be certain that his reference is universally understood.

It often happens that some members of a species possess fairly constant characters which differ in detail. For instance, among domestic cats are tailless Manx cats, long-haired Persian cats, tabbies, and others. These are distinguished as varieties of the domestic cat, *Felis catus*. The variations of domesticated animals produced by a process of "artificial" selection are known as races, or breeds. Common examples are afforded by pigeons and fowls. Fantail, pouter, tumbler, carrier, and many other breeds of pigeon, though differing in size and appearance, are all related to and descended from the blue rock pigeon, *Columba livia*. The small Indian jungle-fowl, *Gallus bankiva*, is the stock from which Indian Game, Wyandottes, Orpingtons, Leghorns, Minorcas, and similar fowls have been derived.

On an evolutionary hypothesis it is implied that those species grouped together in a classification are related, more or less closely; but the classification is not dependent on this idea, for Linnaeus himself believed in the fixity of species. The possession of similar characters, or a similar organization, which is the basis of

classification, is commonly also the evidence for relationship.

The aim of the zoologist is to avoid artificial schemes of classification and to find a good natural scheme. An artificial system might group together bats and birds on the grounds that both possess wings, and whales and fishes because both lead aquatic lives and have fins ; but bats and whales are undoubtedly mammals.

Homology and Analogy

Mention of bats and whales brings us to the two important terms, *homology* and *analogy*. These words mean structural and functional equivalence respectively. Parts of two different kinds of animal which occupy the same relative position and develop in the same way are said to display homology, or to be homologous, irrespective of the kind of work they do. Structures display analogy or are analogous, when they do the same work, though they may be differently placed and develop in different ways. The wings of bats and birds serve the same purpose and are thus analogous, and, further, are developed in the same manner as modified fore-limbs, so that they are also homologous. The wings of birds and insects are analogous, but, because the wings of insects are merely thin outgrowths of the wall of the body, they are not homologous. The term homology is reserved to denote resemblances believed to indicate blood-relationships.

LESSON 3

Major Divisions of the Animal Kingdom

The animal kingdom is divided into three sub-kingdoms, the Protozoa, Parazoa, and Metazoa. The first two contain each a single phylum, the Protozoa and Porifera respectively ; the third contains all other animals. The Metazoa are divided into several phyla, some of which are dealt with here. The remaining phyla are of less importance, containing few, or obscure, animals, whose structure is such as to preclude their inclusion in any of the major phyla. Examples of such animals are the wheel-animalcules (Rotifera), lampshells (Brachiopoda), moss-polyps (Polyzoa), arrow-worms (Chaetognatha), and ribbon-worms (Nemertea).

It is clear that the term phylum does not possess equal significance throughout the animal kingdom. The backboned animals, for instance, constitute the single phylum Chordata, the importance of which far transcends that of the phylum Phoronidea, which contains only a few species of the solitary genus of minute, tube-living marine animals, *Phoronis*.

Many unequal divisions of the animal world are made as a matter of convenience. The phylum Chordata is sometimes called the Vertebrata in contradistinction to the Invertebrata, a collective designation for all other phyla, with which it is often convenient to deal *en bloc*.

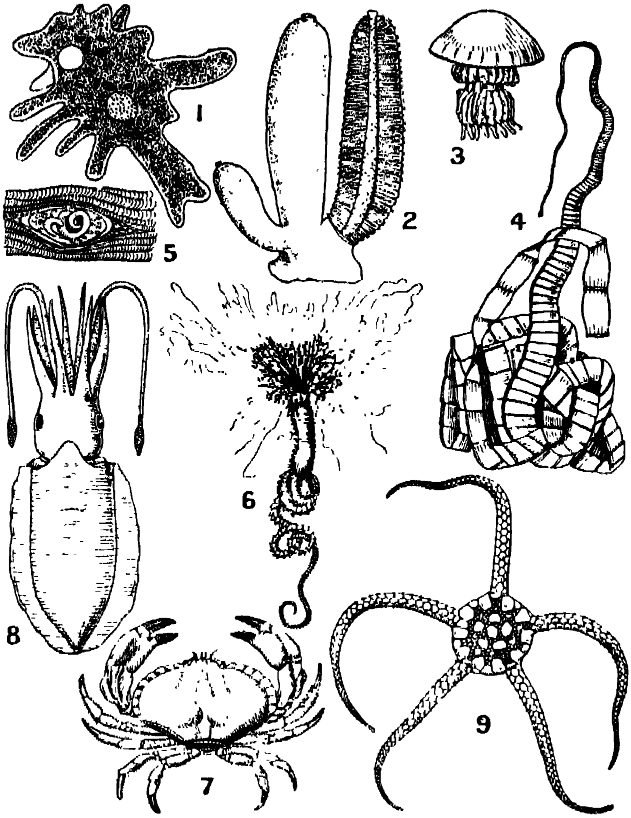
The ten great phyla of animals are arranged in order of increasing complexity of structure as far as is possible, although it should be noted that the phyla do not form a graded series in this respect. The usual expression "tree of animal life" is to be admitted only when it is realized that in such a tree the branches are represented by animals now extinct. No single phylum of animals can be regarded as the linear descendants of any other phylum.

(1) **Protozoa** (animalcules). The vast majorit of members of this phylum are microscopic; The body of a protozoon consists of a single mass of protoplasm devoid of cellular structure ; alternatively it can be regarded as consisting of a single cell.

This is in contrast to the Metazoa, whose bodies are made up of many microscopic units, the cells, each with a central nucleus surrounded by cytoplasm. Some Protozoa possess more than one nucleus, but there is never a division of the cytoplasm. The Protozoa are ubiquitous in distribution, occurring in the sea and fresh water, in soil, and as parasites within the bodies of other animals. Certain Protozoa contain chlorophyll and are therefore plants, though otherwise very similar in structure to forms which have no green pigment and feed as animals. In this division of the Protozoa (the class Flagellata) the animal and plant kingdoms meet, and it is impossible to draw a hard and fast line between them.

(2) **Porifera** (sponges). The sponges might at first sight appear to be plants, being sedentary and with little power of active movement ; the mode of feeding, however, shows that they are animals. The body is divided into cells, but some of these are of a radically different type from any occurring in the Metazoa, and there is little co-ordination of the different parts of the body. As feeding consists in the filtering of minute particles from a stream of water passed through the body, all sponges are aquatic ; most are marine. The bath sponge is the dried, horny skeleton of a colonial form.

(3) **Coelenterata** (polyps and jellyfish). Probably the most familiar members of this phylum are the beautifully coloured sea-anemones, which are to be found attached to rocks between



TYPES OF INVERTEBRATA. 1, Amoeba. 2, Sponge. 3, Jellyfish. 4, Tapeworm. 5, Round-worm. 6, Ringed-worm. 7, Crab. 8, Cuttlefish. 9, Brittle starfish.

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tide-marks on British shores, and the jellyfishes. The Coelenterata are wheel-like or radially symmetrical animals, with a central mouth surrounded by a circlet of tentacles. Corals also belong to this phylum, as do various floating animals such as the Portuguese man-o'-war and the sea-gooseberries. All coelenterates are aquatic, the majority being marine.

(4) **Platyhelminthes** (flat-worms). Most members of this group are unsegmented parasites, tapeworms, and flukes, chiefly notable as sources of disease. Like most parasites they show structural degeneracy and greatly enhanced powers of procreation. But some members of the phylum are free-living and occur both in fresh water and in the sea.

(5) **Nematoda** (round-worms). These animals are often parasites of economic and medical importance. They vary in size from minute microscopic threadworms, found commonly in the roots and stems of plants, to the dreaded yard-long guinea worms of the tropics, which infest the skin and deeper tissues of men and animals and cause dangerous ulcers. There are also many free-living forms which occur almost anywhere.

(6) **Annelida** (ringed-worms). This group includes a vast number of marine worms, as well as earthworms and leeches. Their bodies are segmented, and the leading feature of their structure is the repetition of similar parts or organs, or metamerism, which forms a characteristic feature of the architecture of the bodies of higher animals. In marine worms segments are provided with squat limbs, never divided into joints.

(7) **Arthropoda** (jointed-limbed animals). The animals belonging to this group have a general resemblance to the Annelida in having a body divided into successive segments and a solid brain and nerve cord lying near the lower surface of the body. But the body of an annelid is enclosed in a very delicate cuticle, whereas that of an arthropod has a cuticle sufficiently tough to constitute an armour which must be shed periodically to enable the animal to grow. The process of shedding the cuticle is called moulting or *ecdysis*. The phylum embraces many animal types with jointed appendages, which we recognize as crabs, and their allies—scorpions and spiders, centipedes, millipedes, and insects. This is the phylum with by far the greatest abundance of species, as well as most numerous individuals.

(8) **Mollusca** (shell-fish and cuttlefish). The shell of the animals forming this phylum is produced by a limited part of the body wall, the mantle, and may be a single piece, as in snails, or paired pieces, as in oysters, mussels, and other bivalves, as such molluscs are called : some species no longer have the shell. The body is not divided into segments, and the locomotor organ is a fleshy projection from the lower surface of the animal, the foot. The cuttlefishes and octopuses are the most active forms.

(9) **Echinodermata** (starfish and sea-urchins). The symmetry of the members of this phylum, like that of the Coelenterata, is radial. The mouth is central and is surrounded by a ring-shaped tube, which forms the water vascular system characteristic of the phylum. It gives

off radiating branches which are supported by outgrowths of the body, or arms, and which conduct fluid to minute sucker-like papillae, the tube-feet. There is a skeleton which of all invertebrate skeletal structures most nearly approaches the bone of vertebrates. Some members of this phylum are sessile. All, without exception, are marine.

(10) **Chordata.** The animals here included are distinguished by the possession of a backbone or its equivalent, a hollow, central nervous system lying near the upper side of the body, and perforations of the throat or gill clefts, which are always present during part of the life cycle. Examples of the Chordata were given in the previous Lesson.

LESSON 4

Characteristics of the Protozoa

The Protozoa are of interest in that they throw light on the beginnings of organic structure. They are of small size, mostly microscopic and rarely exceeding the size of a fine grain of sand; with this small size is correlated a characteristic organization.

Movement is effected in a variety of ways among the Protozoa; the types of movement encountered fall into three categories: *amoeboid*, *ciliary*, and *flagellar*, which in part determine the classification of the phylum. Some Protozoa are sessile, and may live as colonies of several individuals more or less closely associated.

Structure and Composition

The protoplasm of living Protozoa has a foam-like composition, consisting of minute bubbles of fluid material dispersed in a more viscid meshwork. This structure can be broken up by the inclusion of granules, or droplets of food or manufactured materials, and of skeletal structures. Protoplasm is a *colloid* solution, consisting of minute particles suspended in a watery medium, and, except at the surface of the animal, is in a *sol* state, behaving as a fluid. Near the surface the protoplasm is more viscous, or is a *gel*; this layer of gel protoplasm is called the ectoplasm, contrasted with the fluid endoplasm. The ectoplasm and endoplasm are not permanent structures, but represent different states of the protoplasm, the sol and gel states being interchangeable. The ectoplasm is bounded on the outside by an extremely thin membrane, of great physiological importance, called the *plasma membrane*; it is not visible by ordinary methods of microscopy, but its presence can be demonstrated by other means.

Lying somewhere within the protoplasm is an ovoid or spherical body, the nucleus, of great importance in the regulation of the life processes enacted within the cell. The nucleus is bounded by a *nuclear membrane*; it consists of protoplasm containing proteins different from those of the non-nuclear protoplasm, or *cytoplasm*.

Apart from granules and food particles, there may be in the cytoplasm a clear vacuole which varies in size, or pulsates. This is the *contractile vacuole*, which is characteristic of Protozoa living in fresh water, but does not occur in marine forms; it may or may not occur in parasitic Protozoa. Substances in solution exert a pressure, the *osmotic pressure*, which will cause water to pass across a certain type of membrane (a *semi-permeable* membrane) separating two solutions of different concentration; water passes from the weaker to the stronger solution until their concentrations are equalised. A semi-permeable membrane is one that is permeable to water, but not to substances dissolved in the water, salt, or sugar or whatever they may be. Protoplasm contains substances in solution at a greater concentration than does fresh water; the plasma membrane acts as a semi-permeable membrane (though no natural membrane is perfectly semi-permeable) so that water constantly enters the body of a protozoon living in fresh water.

The contractile vacuole is a device for bailing this water out again. Water entering is passed into the vacuole, which therefore increases in size, up to a point at which it bursts and expels its contents out through the surface of the animal; a new vacuole then begins to fill up until it too bursts. Marine Protozoa do not have a contractile vacuole because the concentration of salts in sea water is the same as that within their protoplasm, so that water does not tend to pass in. The rate of beat of the contractile vacuole of a protozoon can be altered by putting it into solutions of varying concentration. The vacuole is no longer formed when the concentration of solutes in the outside medium equals that in the protoplasm. If the concentration outside is further increased, the protozoon will shrivel up, as water passes out of its body.

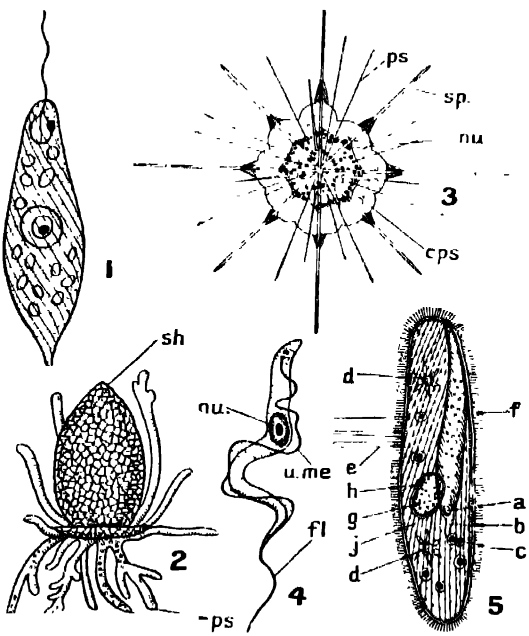
Means of Locomotion

Amoeboid movement is effected by the protrusion of *pseudopodia*, which may be blunt masses, or exceedingly fine filaments, or may be delicate and branching processes sometimes provided with an internal supporting strand. The formation of the blunt type of pseudopod, such as occurs in *Amoeba*, has been studied. First, the ectoplasm at a particular point thickens

and protrudes from the surface ; endoplasm flows into this projection from behind and enlarges it. At the tip of such a pseudopodium the endoplasm which has flowed this far changes from the sol to the gel state and becomes ectoplasm, while the previously formed ectoplasm passes back as a sleeve over the surface of the pseudopod. At the opposite end of the animal, ectoplasm is becoming endoplasm.

Flagella, the agents of flagellar movement, are long lashes of ectoplasm of fixed form, by the undulating or wavering motion of which the body of the animal is drawn through the water. The currents set up may carry minute particles of food material towards the body, thus constituting a feeding mechanism. An internal thread runs along each flagellum and joins a fine granule within the body of the animal.

Cilia, by means of which ciliary movement is effected, are shorter ectoplasmic lashes which occur in greater numbers than flagella. They bend and straighten in a rhythmical manner and serve the same purpose as flagella, and like these structures they possess each an internal filament and a basal granule. Cilia are often fused to form compound structures of varied form. United into conical masses they form *cirri* ; fused side by side they constitute undulating membranes, and sometimes paddle-like organs known as *membranellae*.



PROTOZOA. 1, Euglena viridis. 2, Difflugia urceolata ; sh., shell composed of particles of sand ; ps., pseudopodia. 3, Acanthometra elastica ; ps. pseudopodium ; sp., spine ; nu., nucleus ; cps. central capsule. 4, Trypanosoma brucei ; nu. nucleus; u.me., undulating membrane; fl., flagellum 5, Paramoecium caudatum ; a, mouth ; b, gullet c, food vacuole ; d, contractile vacuoles ; e exploded trichocysts ; f, cilia ; g, macronucleus ; h, micronucleus ; j, contractile fibrils

Reproduced by permission from Borradaile, Eastham, Potts and Saunders, "The Invertebrata", Fig 5 from Shipley & MacBride, "Zoology." Cambridge University Press

The surface of living Protozoa varies in nature : in amoebae it consists simply of the ectoplasm covered by the plasma membrane, though some relatives of *Amoeba* also secrete shells, in which they live. In some Protozoa the outer ectoplasm may be very stiff and called a pellicle, as in *Paramoecium*, or there may be a tougher covering, of dead material, called a cuticle, as in the *Sporozoa*. In some flagellated animals the covering may be composed of relatively stout plates of cellulose, the supporting material of plants. Chalky or flinty shells are commonly seen in the *Foraminifera*, and in animals like *Difflugia* the shell is strengthened by having foreign bodies, such as sand grains, built into it.

Methods of Nutrition

In most animals nutrition is *holozoic*, by which is meant the swallowing through temporary or permanent openings in the body of complex organic materials. This type of nutrition is also met with in the Protozoa. Amoeboid members of the Protozoa make use of pseudopodia for feeding purposes, embracing and engulfing the prey by such protoplasmic protrusions at any point in the surface of the animal. Other members swallow through a permanent mouth and gullet ; for instance, *Paramoecium*. The gullet may have a ciliary apparatus and protoplasmic stinging and paralysing elements, or trichocysts. The tentaculate *Suctoria* draw their prey into their bodies by way of tentacles. Defecation of indigestible matter takes place at any part of the surface, except in forms with a pellicle, when it occurs at a fixed point.

Not all Protozoa are holozoic feeders, however; some *Euglena*, for example—are *holophytic*, that is, behave as plants, and build up complex organic substances from simple inorganic ones by utilising the energy of sunlight. Such Protozoa contain chlorophyll. Others are *saprophytic* or *saprozoic*, that is, take in through the surface of the body complex organic compounds derived from animal or vegetable remains, or, in parasitism, from the body fluid of another living organism.

Encystment and Reproduction

Many Protozoa are able to resist desiccation for long periods of time. Some either occasionally or regularly spend a period of their lives in a tough coat called a cyst, which serves to prevent drying out of the fluid protoplasm. Encystment, the process of cyst formation, is common in parasitic forms, as also in forms which live in fresh water and thus may be

accidentally exposed to conditions of drought. In species which live in the sea, encystment is less common. In many instances the cyst serves to shelter the animal while it undergoes a process of reproduction. Such a cyst is called a *gametocyst* where the reproduction is sexual, a *sporocyst* where it is asexual.

Asexual reproduction is widespread in the Protozoa, and most commonly takes place by a process of *binary fission*. The animal having grown to a certain size, first the nucleus divides, then the cytoplasm becomes constricted so that the body splits into two, each half with a nucleus. The division may be transverse or longitudinal according to the species concerned. Fission may alternatively be *multiple*, when the protozoon first becomes multi-nucleate by repeated division of the nucleus, followed by division of the cytoplasm into as many pieces as there are nuclei. Other types of asexual reproduction, such as budding, occur.

Sexual reproduction in the Protozoa may consist either in the fusion of two sex-cells (*gametes*), a process known as *syngamy*, or of *conjugation*, during which there is exchange of nuclear material between two individuals, without permanent fusion of their cytoplasm.

It is not uncommon to find that Protozoa pass through a cycle of generations of individuals of different kinds. For a time the Protozoa may multiply repeatedly by asexual fission, but ultimately a generation arises which produces gametes, and is therefore known as a generation of *gamonts*. The union of the gametes from such individuals in pairs produces an individual called a *sporont*, which reproduces asexually to produce a large number of individuals each of which ultimately becomes an agamont, that is, an individual which repeats the asexual part of the cycle. The term spore is reserved for the products of multiple fission of the sporont, or zygote, produced by the union of gametes.

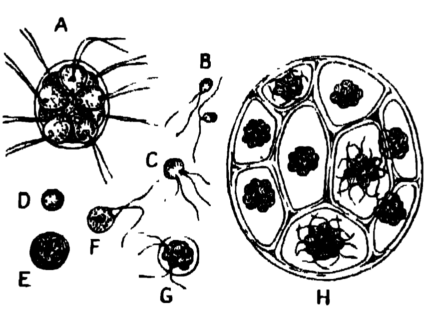
LESSON 5

Classification and Types of Protozoa

The phylum Protozoa is divided into five classes, the Flagellata (or Mastigophora), the Rhizopoda (or Sarcodina), the Sporozoa, the Ciliata, and the Suctoria. The names of the classes suggest their habits, for the Flagellata move by means of flagella, the Ciliata by means of cilia; the Rhizopoda have pseudopodia. The Sporozoa are parasitic forms with complex life histories including the formation of spores at some stage. The Suctoria are sessile forms with tentacles with which they catch their prey and suck it into the body.

The class Flagellata probably contains the most primitive members of the phylum. The view that the Rhizopoda—with the type of organization seen in the amoeba—are primitive is now generally discarded. The apparent simplicity of structure is not necessarily primitive, and the mode of nutrition (holozoic) is definitely more specialised than that of some of the Flagellata.

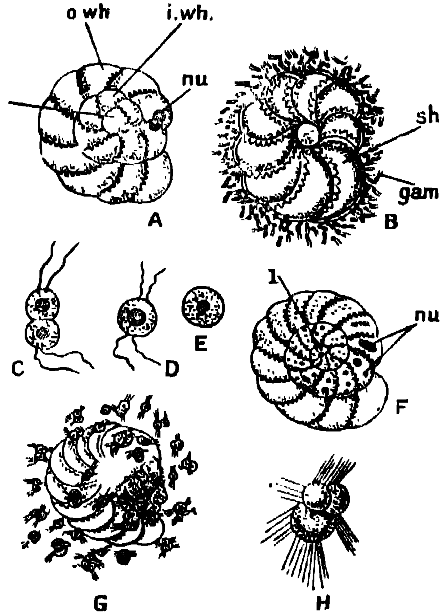
One of the commonest flagellates is *Euglena*, which lives in such abundance in ponds and ditches that the water often appears to be coloured a vivid green. There are about 50 species of the genus. *Euglena* is spindle-shaped and has a minute mouth and gullet near the blunter end of the body. A long flagellum, which arises from the inner surface of the gullet, serves to draw the animal through the water. The animal frequently changes its form: at one time it is short and stumpy; at another, long and slender. These alternate contractions and elongations serve a locomotory function and constitute the type of movement known as *euglenoid*. Near the middle of the cell is a spherical nucleus and near the blunt end a contractile vacuole, which discharges into the gullet. The green colour of the animal is due to *chloroplasts* containing chlorophyll scattered throughout the cytoplasm, which also contains rod-shaped masses of paramylum, a starch-like food reserve. A bright red spot near the base of the flagellum is sensitive to light. *Euglena* feeds by a combination of the holophytic and saprophytic methods, never taking solid food; it cannot maintain itself by light and inorganic matter alone, requiring always some organic matter as well. In the dark it feeds entirely saprophytically. Reproduction in *Euglena* is always asexual, by longitudinal fission.



PANDORINA. A, colony of zooids. B-G, stages in sexual reproduction; B, motile gametes; C, after fusion of two gametes; D, flagella withdrawn; E, resting zygote with thickened wall; F, motile individual produced by the zygote on germination; G, new colony produced by vegetative division of the motile individual; H, colony undergoing a sexual reproduction; each zooid has divided to form a daughter colony; some of the colonies have produced flagella and will shortly break out of the parent cell.

A relative of *Euglena* called *Chlamydomonas* has two flagella and a close-fitting

cuticle, and this type of flagellate leads to the interesting allied form *Pandorina*. *Pandorina* consists of 16 pear-shaped cells, each with the organization of *Chlamydomonas*, bound together in a common covering to form a colony. Reproduction of such a colony obviously cannot be so simply effected as in the solitary forms. It takes place by one of two methods, one sexual, the other asexual. In asexual reproduction each zooid of the colony divides repeatedly to form a group of 16 cells, so that the colony now consists of 16 colonies of minute daughter flagellates. Dissolution of the common envelope follows and liberates the daughter colonies, which then grow until identical with the original parent colony. In sexual reproduction each individual of the colony divides to form male and female gametes, which unite in pairs to give rise to zygotes. The zygote rests for a while in an encysted condition, then becomes a free flagellate, and finally undergoes repeated division to form a colony resembling the parent one.



POLYSTOMELLA. A, megascleric form ; B, shell of some surrounded by escaping gametes ; C, D, conjugation ; E, zygote ; F, microscleric form ; G, shell of same surrounded by escaping amoebulae ; H, young megascleric individual with three chambers ; gam., gametes ; i.wh., inner whorl of spiral ; o.wh., outer whorl ; nu., nucleus ; sh., shell ; 1., first chamber.

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Volvox and Trypanosomes

Colony formation reaches perfection in *Volvox*, where large numbers of biflagellate zooids collectively constitute a hollow sphere filled with fluid. It is not uncommon to see, swimming about in the central fluid, three types of reproductive units, clusters of male and female gametes and asexually-formed spherical daughter colonies. These have been formed by division of zooids making up the wall of the parent colony. Some enlarge and form ripe spherical female gametes (*megagametes*), others divide repeatedly to produce smaller ripe male gametes (*microgametes*), each with an elongated body, two flagella, and a minute red eye spot. The microgametes swim freely in the fluid contained in the central cavity of the colony, and eventually unite each with a megagamete to give rise to a zygote. The latter subsequently divides repeatedly to found a new colony.

Those dangerous parasites of mankind and domesticated animals, the trypanosomes, also belong to the Flagellata. They are of slender, pointed form and possess a pellicle. The animals live in the blood and other fluids of the host and absorb food materials through the pellicle. Accordingly, there is little need for a mouth and gullet, and these are lacking. A delicate undulating membrane serves as a locomotor organ. The contractile vacuole is absent.

These flagellates are invariably distributed by a second host. *Trypanosoma gambiense* and *T. rhodesiense*, the agents of sleeping sickness in man, which are found in the fluid of the spinal cord, are transmitted by the tsetse fly, as is *T. brucei* which causes fever in African domestic mammals. Not all the trypanosomes are dangerous to their hosts ; *T. lewisi*, for instance, occurs in rats but is not pathogenic ; it is transmitted by a flea.

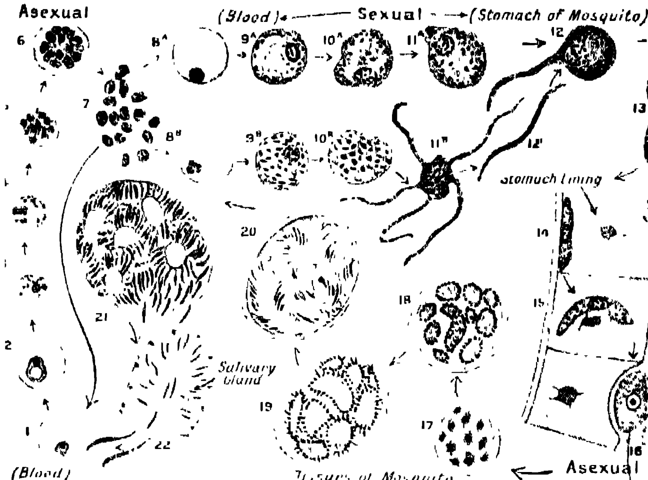
The Rhizopoda class is characterised by the presence of pseudopodia. The rhizopods appear to have been derived from the flagellates, for some of them also bear flagella. Feeding is holozoic, food being captured by the pseudopodia. Reproduction is usually asexual, by binary fission, sometimes by multiple fission, but sexual processes occur in some species. *Amoeba*, one of the best known forms, consists of an irregular mass of protoplasm, which is produced into numerous blunt pseudopodia of constantly changing form. The ectoplasm is clear and translucent.

Difflugia is a relative of *Amoeba* which has a shell of foreign particles set in a matrix secreted by the animal.

Allied to the common *Amoeba* are parasites, of the genus *Entamoeba*. One species, *E. coli*, lives harmlessly in the intestine of man ; another, *E. histolytica*, causes amoebic dysentery.

Complicated Life History

Rhizopods of the order Foraminifera are marine, some living on the bottom and some in the surface waters, enclosed in a finely perforated shell. The protoplasm is protruded through minute pores in the shell in fine reticulate



LIFE CYCLE OF MALARIA PARASITE. Development of the malarial parasite in the human host is shown in Figs. 1 to 7. Female and male forms (8a and 8b) may also develop, and these (9a to 13) mature in the stomach of the mosquito which has taken up blood containing them. Thereafter the parasite in the stomach wall of the mosquito develops until a fresh swarm of young is produced; these make their way into the salivary gland of the insect, ready for injection into a fresh human host (14 to 22).

pseudopodia. The shell has usually several chambers and is frequently spiral, with communicating chambers; it is composed of chalky, flinty, or nitrogenous materials in different types. *Polystomella* is an interesting example, since it is of complex form and has a complicated life history. It is a dimorphic creature, that is, it can occur as either of two kinds of individual. These are distinguished by differences in size of the inner, first-formed chambers of the spirally-wound compound shell. Individuals with a small central chamber are microscleric, those with a larger central chamber megascleric. The microscleric individual multiplies by asexual fission, giving rise to and liberating numerous minute irregular protoplasmic masses, or amoebulae, each of which forms a shell around itself and grows into a megascleric individual. The megascleric form reproduces sexually, giving rise to numerous bi-flagellate gametes, which unite in pairs to form a zygote. Later this develops into a microscleric individual. The life history of *Polystomella* shows alternate production of asexual and sexual forms, or an alternation of generations.

The Foraminifera have played a part in building up many limestones. At the present time the remains of their shells fall as a constant rain on the floor of the ocean, where they accumulate to form limy oozes. Microscopic examination of chalk, which is a very pure limestone, shows that it consists of such shells, which accumulated in an ancient sea that stretched from what is now the Atlantic eastwards through south Europe to Asia.

Radiolarians

Members of the order Radiolaria occur in the surface strata of the sea. There are fine pseudopodia, and the protoplasm has a characteristic bubbly appearance. These animals do not possess a shell, but have a central capsule and a skeleton of fine spicules of a flinty nature bound together into an intricate lattice-work with projecting spines. These shells sink when the animals die, and cover vast expanses of the floor of the deeper parts of the ocean to form radiolarian oozes.

The fresh-water sun animalcules or *Heliozoa* are, like the radiolarians, spherical, and have vacuolated protoplasm, but lack a central capsule. The radially arranged pseudopodia have clear axial supports of dense protoplasm and in consequence they are called *axopodia*.

The animals composing the class Sporozoa live as parasites, many within the cells of the body of the host. Large numbers of spores are produced and the life cycle is particularly complicated. The chances of finding a suitable host are remote, necessitating the production of large numbers of potential adults.

Blood Parasites

As an illustration of the Sporozoa, there are the blood parasites known as *Haemosporidia*, which are transmitted from one vertebrate host to the next by a blood-sucking invertebrate. *Plasmodium*, the cause of malaria in man, lives in and destroys the red corpuscles of the blood and is transmitted by the mosquito *Anopheles*. When the parasite enters a blood corpuscle it is a minute rounded body with a central vacuole. With the enlargement of the vacuole, the young animal comes to have the appearance of a microscopic signet ring. It has a nucleus but no mouth, absorbing food materials through its entire surface. It grows and gradually loses the ring-like form, and granules of pigment (derived from the digestion of the material of the corpuscle) accumulate in the cytoplasm. When ready to multiply it is called a *schizont*, and its mode of reproduction, multiple fission, is known as *schizogony*. The nucleus divides repeatedly until 16 smaller nuclei are present. By the arranging of a little protoplasm around each nucleus a rosette of nucleated individuals (merozoites) is formed.

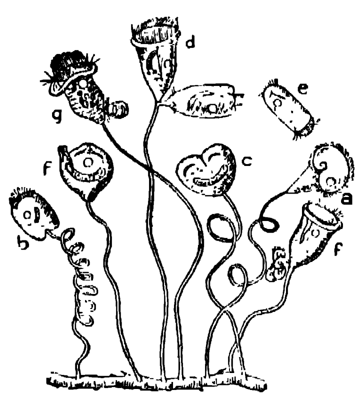
At the rosette stage in schizogony, the wall of the red blood corpuscle breaks down, and the merozoites are set free in the blood, each one proceeding to infect a fresh corpuscle—there to repeat the cycle and to multiply. At this stage also fever occurs, probably because the residual protoplasm at the culmination of schizogony contains an accumulation of poisonous elements which are liberated into the blood. Three species of *Plasmodium* infect man, and the time taken to complete schizogony—and therefore the period between successive bouts of fever—varies according to the particular species. *P. vivax* sets free a generation of merozoites in 48 hours, so that fever recurs every third day (tertian malaria); *P. malariae* liberates the zooids every 72 hours, fever recurring every fourth day (quartan malaria); *P. falciparum*, causing malignant, or pernicious, malaria of the tropics, is dangerous because the infected corpuscles adhere in clumps and may block the blood capillaries in important organs.

After several generations of schizonts have appeared, gametes—called crescents on account of their form are produced. These remain quiescent unless drawn up in the blood by the piercing and sucking proboscis of the mosquito. Taken into the food canal of the insect, the male gamete becomes slender and whip-like, the female gamete spherical. Conjugation occurs and a spindle-shaped zygote is formed. The zygote bores its way through the wall of the mosquito's stomach and forms a cyst on the outer side of the stomach wall. Within the cyst repeated fission occurs and enormous numbers of individuals are formed. These are sporozoites, and when the cyst bursts they make their way to the salivary glands. The female mosquito bites man, inoculating a small quantity of parasite-infected saliva into the wound. Infection of the corpuscles follows.

Types of Ciliate

The members of the class Ciliata are characterised by the possession of cilia, used for locomotion and feeding. In most ciliates there are two nuclei, a large *macronucleus* concerned with the general regulation of the cell, and a small *micronucleus* concerned only with reproduction. Asexual reproduction is by binary fission, usually transverse; sexual reproduction by conjugation, not syngamy. Feeding in most members of the group is holozoic; some are parasitic. The most highly organized Protozoa are to be found in this group.

Paramoecium is a type of ciliate which is uniformly clothed with short cilia, one of the order Holotricha. It may be obtained readily by infusing a few fragments of hay in water for several days. There are about ten species of the genus. The animal is slipper-shaped, from which the common name slipper animalcule is obtained, and the "heel end" goes foremost when the animal moves. A pallicle covers the body, and below this is a layer of ectoplasm, bearing cilia in regular longitudinal rows. The permanent mouth and gullet lie on one side of the animal, and there is a definite anal orifice. Among the cilia lie fine protrusible stinging threads, or *trichocysts*, capable of paralysing animals with which they come into contact. The macronucleus lies beside the micronucleus (some species have two or more micronuclei) and two contractile vacuoles occupy opposite ends of the cell, surrounded by numerous fine canals which radiate into the surrounding cytoplasm, and discharge into the vacuole.



VORTICELLA. Stages of life history; a, ordinary individual; b, same contracted; c, ordinary fission; d, later stage of same; e, free-swimming individual produced by fission; f, f, two modes of fission to form micro-conjugants; f (left), budding; f (right), repeated fission of one product of a binary fission; g, conjugation.

Asexual reproduction of *Paramoecium* takes place by simple, obliquely transverse fission. Of the two individuals thus formed, one lacks the mouth, but soon forms a new one. The asexual mode may proceed through many generations, but sooner or later a process of conjugation occurs. When this happens, two individuals lie close together, side by side, and complex nuclear changes occur within the body of each. The macronucleus degenerates and disappears, but the micronucleus grows and divides. Interchange of pieces of the micronucleus now takes place, after which the two individuals separate and proceed to reconstruct the normal nuclear apparatus. Asexual reproduction can then proceed for a number of generations further. The process of conjugation appears to be essential for the well-being of both individual and species.

Cultures of *Paramoecium* in which conjugation is prevented soon fall into an unhealthy condition called depression, in which the body is stunted, the nucleus overgrown, and various organs degenerated. If allowed to conjugate, such individuals recover their former vigour. It is not the only method of regaining lost vigour, however, for it has been shown that a process resembling conjugation and called *endomixis* occurs in such weakened individuals

as are seen in culture depression. This takes place within the individual and therefore does not involve union or exchange of nuclear particles, but it is a reorganizing process no less, in which the meganucleus degenerates and the micronucleus divides, one of the resultant particles forming a new macronucleus.

Physiological Complexity

Vorticella is a ciliate of the order Peritricha in which cilia are restricted to a ring-shaped zone around the mouth. The form of the body is that of an inverted bell, permanently fixed to fresh-water weeds by a long, slender stalk, a prolongation of the body containing a fine contractile fibril. In life the animal slowly expands to the full length of its tether, at the slightest untoward stimulus contracting its stalk into a close spiral. The margin of the bell is thickened and within it lies the mouth, leading into a gullet, The cilia as in the *Paramoecium*—are arranged so as to waft food particles down the gullet at the base of which they are taken into the body. The large contractile vacuole discharges into the gullet. *Vorticella* has a small spherical micronucleus and a crescentic macronucleus. Asexual reproduction occurs by longitudinal fission. In this event two bells occur on a single stalk. Some near relatives of *Paramoecium*—*Carchesium*, for instance—exist normally in the form of pseudo-colonies, many bells occurring on a single stalk ; but *Vorticella* is typically solitary, and when fission occurs one of the individuals acquires a basal circlet of cilia and swims away, ultimately to fix itself and develop a new stalk. Occasionally fission may be irregular and several microzooids are formed ; these individuals swim away, ultimately to conjugate with an individual of normal size.

The Protozoa are of zoological interest in that the apparently simple protozoan cell shows great physiological complexity. The protozoon carries out all the functions of life without division of the body into separate cells, as in the Metazoa. The acellular state is probably correlated with the small size of the animals. The class Flagellata is of particular interest in that within it the plant and animal kingdoms meet. It gives some idea of what the earliest animals may have been like.

LESSON 6

The Structure and Habits of Sponges

The sub-kingdom Parazoa contains only a single phylum, the Porifera. The body of a sponge is a community of cells showing less complete integration than in the bodies of the Metazoa ; there are no definite organs

Sponges are invariably aquatic animals which are sessile, usually in the sea, attached to rocks and stones, on the surfaces of which they often form conspicuous incrustrations. Though rich in species and strong in numbers, they appear not to have led on to any other forms of life. The multicellular body is vase-like in its simplest form and consists of two layers of cells, between which a structureless jelly, or *mesogloea*, containing wandering cells, is interposed. This simple form is best shown in the *olynthus*, a transitory stage in the development of calcareous sponges.

The Olynthus Stage

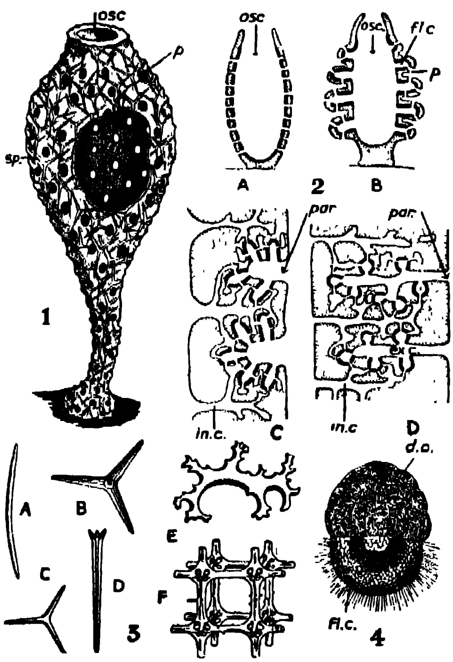
The olynthus is a living vase through which water currents constantly circulate. At its upper extremity is a large aperture, the exhalant aperture, or *osculum*, by way of which water leaves the central cavity, or *paragaster*, of the body. Water enters the sponge through numerous minute pores scattered over the entire surface. The current is produced by the activities of peculiar flagellated cells with delicate protoplasmic collars (collar-cells or *choanocytes*) which line the paragaster, lying side by side in loose contact with each other.

The inhalant pores are perforations of special cells known as *porocytes*. These are of conical form and extend throughout the mesogloea, their apices lying between clusters of choanocytes, and their bases being inserted between the *pinacocytes*—flattened cells forming the outer layer of the sponge ; the pore is a narrow channel which passes through the porocyte from base to apex. The mesogloea contains cells of various kinds, some of which wander into the jelly from the outer layer and secrete the skeletal framework of the sponge. These are called scleroblasts and usually divide each into two cells, one of which secretes a spicule, while the other thickens. In the olynthus such cells aggregate in groups of three, to give origin to three-rayed spicules which build up the main part of the skeleton in this form. Single-rayed spicules also occur, and project some little distance from the surface of the body. Other cells in the mesogloea are amoeboid and perform various functions. Some transport food materials and waste products through the body of the sponge ; others ultimately give rise to male and female reproductive elements or gametes. But nerve and sensory cells, and muscles, commonly found in the bodies of metazoa, are absent, indicating that little co-ordination occurs in sponges.

No existing sponge remains at the primitive stage represented by the olynthus, however. The simplest living forms consist of a number

of branching tubes, each tube with the structure of an olynthus, and topped by an osculum. An example is *Leucosolenia*. This type of structure is known as the *ascon*, because manifested by sponges of the genus of this name. Sponges of the second or *sycon* type, typified in the genus *Sycon*, may be solitary but have the walls folded and the choanocytes restricted to radial chambers. Further complications may result in the production of thimble-shaped outgrowths of the chambers, a condition constituting the *leucon* type of sponge structure. This may be still further modified by means of reduction of the flagellated chambers until they are small and spherical.

With the complication of the wall of the sponge comes inadequacy of the nomenclature previously adopted. In a sycon type of sponge the passages leading towards the thimble-like flagellated chambers from the outside world and towards the paragaster from these chambers are known as inhalant and exhalant canals respectively, the actual external openings being called *ostia*. In the leucon type the ostia lead into inhalant canals and these into finer canals of a second (and sometimes a third) order before reaching the flagellated chambers. As the canal system becomes more complex, the skeletogenous layer supporting the canals becomes correspondingly modified, growing thicker and forming, outside the chambers, a cortex through which the inhalant canals ramify.



MORPHOLOGY OF SPONGES. Fig. 1, The olynthus of a calcareous sponge with part of wall cut away to expose the paragaster; osc., osculum; p., pore; sp., spicule. Fig. 2, Canal system of sponges; A, Ascon type; B, Sycon type; C, Leucon type; D, Leucon with small round flagellated chambers; ex.c., exhalant canal; in.c., inhalant canal; fl.c., flagellated chamber; osc., osculum; par., paragaster; p., pore. Fig. 3, Types of sponge spicules; A-E, from Demospongiae; C, three-rayed compound spicule formed by union of monaxons; F, from a hexactinellid. Fig. 4, Larva (amphiblastula) of Sycon raphanus; d.c., dermal cells; f.c., flagellated cells.

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Types of Sponge

The types of structure described all occur within the first of the three classes of sponge, namely the Calcarea. The class is distinguished by the possession of spicules composed of chalky material alone, and by the possession also of relatively large choanocytes. Sponge spicules are of various types. Besides the monaxon and triaxon spicules occurring in the olynthus, four or six-rayed and irregular spicules occur in other classes. The second class, Hexactinellida, contains sponges with a purely flinty skeleton composed of six-rayed spicules often bound together to form a very beautiful and intricate mesh-work, best shown in Venus's flower-basket (*Euplectella*). Another elegant form is the glass-rope sponge (*Hyalonema*), native to Japanese seas, which lives rooted in the mud by a slender stalk of long, glassy spicules.

The third class, the Demospongiae, never possess six-rayed spicules, and instead of the flinty skeleton found in some members of the class there may be a horny, proteinaceous skeleton of spongin. The usefulness of the bath sponges, *Euspongia* of the Mediterranean and *Hippospongia* of the West Indies, which have small rounded flagellated chambers, depends upon the spongin character of the skeleton.

Reproduction Processes

Asexual reproduction takes place by the formation of bud-like outgrowths, which ultimately drift free and found new individuals, or by the formation of internal buds called *gemmules*, a process occurring in the one family of fresh-water sponges, the *Spongillidae*. Towards the winter certain cells of the mesogloea become aggregated into clumps and surrounded by a protective capsule, often provided with capstan-like spicules called *amphidiscs*. As winter approaches, the sponge suffers from food scarcity and cold and eventually dies, but the gemmules are liberated from the moribund body of the parent and survive the winter by lying dormant in the mud. During the following spring they develop into new sponges. Gemmule formation ensures the maintenance of life, in spite of the rigour of winter. The new individuals are male or female

and produce gametes, by the union of which a zygote is formed to carry on the racial history.

Many sponges are unisexual, but some are hermaphrodite, that is, produce male and female gametes in the same individual. Male and female gametes appear to arise from amoeboid cells in the mesogloea, but the mode of reproduction varies in different sponges. In all types of sponge the young are of totally different appearance from the parent, and such larvae develop into an adult sponge by means of complex reorganizing changes. The typical larva of Calcarea such as *Sycon* is the *amphiblastula*, which has flagellated cells reaching from one pole to its equator, and large granular cells, devoid of flagella, at the opposite pole. These larvae swim actively before attaching themselves to the substratum and undergoing metamorphosis into the adult form. The non-flagellated cells become pinacocytes, parocytes, and scleroblasts, while the flagellated cells differentiate into choanocytes and various kinds of amoebocyte.

Sponges possess marked powers of regeneration, the property of reconstructing the whole from a part. A small fragment of any living sponge will, under suitable conditions, regenerate an entirely new and complete animal. More than this, if a sponge is cut into fragments and the fragments are squeezed through fine silk, the separated cells are capable of uniting to form clusters which, in the course of a few days, mould themselves into a complete miniature animal. Cells from different species may, if mixed, adhere temporarily, but they soon separate.

Sponges occur in all parts of the sea and at all depths. They are apparently distasteful to fishes, shellfish, and crabs, and are little molested by any forms of life. The boring sponge, *Cliona*, can penetrate the shells of oysters and other bivalves or other calcareous matter. Some species of sponge live in close association with other animals. One species (*Ficulina*) forms the cavity in which a hermit-crab, *Eupagurus*, lives in retirement.

LESSON 7

Marine Animals that Resemble Plants

Most people who have spent holidays on the sea coast will have encountered members of the phylum Coelenterata. Certain of these look so like plants that they were at one time called zoophytes. The phylum is characterised by radial symmetry (which may be only approximate) and by the possession of stinging cells. The only body-cavity is the gut, which has a single opening to the exterior, the mouth, usually surrounded by tentacles. All coelenterates are carnivorous. The animals are sometimes spoken of as *diploblastic*, or two-layered, because the body consists of an external layer, the *epidermis*, and the gut lining, or *gastrodermis*, separated by a layer of jelly, the *mesogloea*. Since in most forms the mesogloea also contains cells this description is not strictly accurate, but it is true in so far as the muscles arise from the outer or inner cell layers, but never as a separate third layer as they do in other Metazoa.

Polyp and Medusa

Two characteristic body-forms occur among the coelenterates: the *polyp*, which is sessile, usually columnar with tentacles and mouth at one end, and the *medusa*, a bell-shaped or umbrella-shaped swimming form with the tentacles arranged round the rim and the mouth in the middle of the under surface.

The Coelenterata are divided into four classes, the Hydrozoa, Scyphozoa, Anthozoa, and Ctenophora. Some authorities place the Ctenophora in a separate phylum on the ground that they do not have the same type of stinging cells as the other three classes.

The Hydrozoa may be either polypoid or medusoid individuals, many of the former being colonial; these are the zoophytes proper, for the delicate branching colonies may look very plantlike, and their dried and dyed skeletons are indeed sold as "sea-fern." One such form, *Sertularia*, is shown in page 2040.

Miniature Forests

An example of the Hydrozoa is *Obelia*, the knotted thread hydroid, colonies of which form miniature forests, often on the fronds of the ribbon-weed (*Laminaria*). The individuals or zooids of the colony are borne at the ends of the fine branches.

So much can be made out with a small hand lens. Using a microscope, it can be seen that the zooids are tiny polyps, each with a terminal mouth surrounded by a circlet of fine tentacles; these are the *hydranths*, the food-getters for the colony. Other branches end in small swellings or buds, which are hydranths in the making; others are a different nature and perform a different function. These last are cylindrical zooids—*blastostyles* as they are called—found near the base of the colony in fewer numbers than the hydranths. They bear small outgrowths which, according to their age, may be insignificant blobs or prominent saucer-like bodies called *medusa-buds*.

All the zooids are connected by stalks enclosed in a transparent, horny investment,

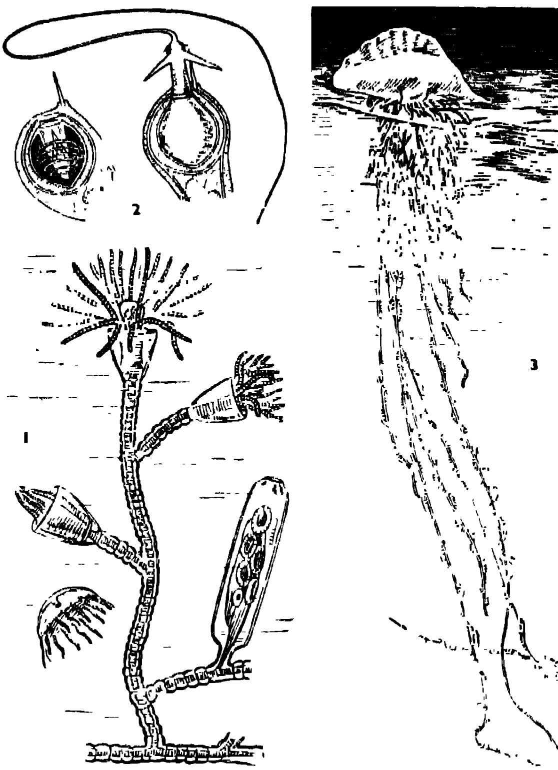
the *perisarc*, which widens out at the base of each hydranth to form a goblet, or *hydrotheca*. The blastostyles have similar sheaths called *gonothecae*. Hydranths, blastostyles, and stalks are composed of epidermal and hypodemal layers, separated by a thin mesogloea. Scattered in the ectoderm, especially in the tentacles, are the stinging cells, or *cnidoblasts*, each containing a vesicle with a spirally coiled thread inside it. On stimulation of the *cnidocil*, a fine bristle projecting from the cnidoblast, the thread can be projected by being turned inside out. The threads can penetrate prey and inject a paralysing poison. Beneath the epidermis lies a net of nerve cells, not highly differentiated but yet serving to co-ordinate the various parts of the animal, or of the colony. Sensory cells, responding to tactile and chemical stimuli, project between the epidermal cells and are connected with the nerve net.

Life Cycle of Obelia

Small animals coming into contact with the tentacles are caught and killed by the nematocysts, and pushed into the mouth. The cells of the gastrodermis secrete *enzymes* (organic catalysts) whose action is to break down some of the proteins of the food, making a broth of half-digested food. Digestion is completed inside the gastrodermal cells, which put out pseudopodia and actively ingest particles of food. Any undigested residue of the food is passed out of the mouth.

The blastostyles do not possess mouth or tentacles, but receive food materials from the hydranths. There is thus a division of labour between the hydranth polyps, specialised for feeding, and the blastostyles, which are specialised for asexual reproduction.

The blastostyles bud off individuals which develop into medusae ; they escape from the gonotheca and swim away. The *Obelia* medusa is saucer-shaped, with numerous tentacles. A projection from the under surface, the *manubrium*, bears the mouth, which opens into a central cavity continuous with four radial canals and a marginal canal, lined with gastrodermis. The medusae are sexual individuals, either male or female. The sex-organs, or *gonads*, lie beneath the radial canals. Male or female gametes are produced in the gonads and shed into the sea, where fertilization occurs. The fertilized eggs develop into small, ciliated larvae, called *planulae*. The planula has a ciliated epidermis outside a central mass of gastrodermal cells, but there is no mouth. There are, however, nematoblasts and nerve cells. The planula larva swims for a time by means of its cilia, but then settles on a suitable surface and becomes attached ; it grows into a polypoid individual which buds other polyps and so forms a colony.



COELENTERATA. Fig. 1, Part of a colony of Obelia with three polyps in various stages of expansion, and at the base a blastostyle on the right and a free-swimming medusa on the left. Fig. 2, Two stinging capsules of a coelenterate ; that on the left is undischarged, the one on the right has shot out its thread. Fig. 3, Physalia, the Portuguese man-of-war, a colony of polyp-like individuals united into a single mass with trailing tentacles.

After drawings in "The Science of Life," by H. G. Wells, Julian Huxley and G. P. Wells

The life cycle of *Obelia* consists of an alternation of asexual colonial forms and sexual free-swimming individuals ; nevertheless some authorities consider this is not a true alternation of generations, as comparison with other coelenterates suggests that the polyp generation may represent only an elaboration of larval life, the medusa being the true adult.

Tubularia and Hydra

There are some hydroids in which the medusoid stages are never set free, but remain attached as modified reproductive zooids. One such form is *Tubularia*, with straw-like hydroid. In other hydroides no special reproductive

zooids are developed. *Hydra*, a solitary polyp of English ponds, is an example of such a type. The gonads of *Hydra* develop beneath the epidermis of the polyp, and the fertilized eggs develop into polyps ; there is no medusa. Conversely, in some Hydrozoa, the *Trachylina*, the medusoid phase is predominant.

Siphonophora

One order of Hydrozoa not yet taken into consideration here is the Siphonophora, an order in which division of labour and colony formation reach heights not attained elsewhere in the class. Siphonophores are delicate, transparent, floating colonies of zooids found abundantly in tropical seas and occasionally drifting towards the Devon and Cornish coasts in the waters of the Gulf Stream. Each colony originates from a planula larva, which develops into an individual with a thread-like process on which all other individuals of the colony are formed later as buds. The first-formed individual usually becomes modified into a gas-filled chamber, a float, or as a medusa-like form which pulsates and serves as a motile zooid.

The full-grown colony is a very elaborate collection of different zooids. Some individuals develop mouths and constitute the breadwinning section of the colony, securing, digesting, and distributing food materials for the rest of the colony. All other zooids lack mouths, and are modified in various ways. Some produce the reproductive elements ; others grow out into leaf-like processes, which overhang and protect other parts of the colony ; another type develops long tentacles that trail below the colony and are armed with formidable batteries of stinging cells.

Physalia, the Portuguese man-of-war, is one of the most formidable members of the Siphonophora. It combines glossy transparency with delicate shades of blue, violet, and carmine, and the colony glistens with a silvery sheen. The feeding zooids can capture, dispatch, and devour quite large fish, and the powerful batteries in the tentacles can sting so severely as to endanger human life. The nearly related deep indigo-coloured *Velella* has a disk-shaped colony which at first sight resembles a single medusa, but actually consists of a large feeding zooid with a centrally placed mouth, around which are several rings of reproductive zooids and a marginal ring of tentaculate stinging zooids.

LESSON 8

Jellyfish, Anemones, Corals, and Ctenophores

The jellyfish most commonly seen on the coasts of Britain is *Aurelia*, a transparent pale blue saucer with four horse-shoe shaped gonads of deep mauve. Two other jellyfish which may be seen are *Cyanea* and *Chrysaora*, dark blue and brown respectively, both of which have an unpleasant sting ; *Aurelia* cannot sting hard enough to hurt a man.

These jellyfish, and numerous others, belong to the class Scyphozoa. They are medusae, but being larger than most hydrozoan medusae are of a more elaborate form. The jelly is a thick mesogloea, mostly situated in the upper half of the bell ; it is not structureless but contains cells and fibres of various sorts and may have quite a stiff consistency. The presence of so much jelly means that a scyphozoan's body consists of about 96 per cent. water.

Life of a Jellyfish

Small tentacles fringe the bell of *Aurelia*, while below it hang four projections of the manubrium, the *oral arms*. In *Aurelia* the digestive cavity is broken up into numerous radiating canals, some branched, some not, and a marginal canal. The food consists of small, floating animals which become stuck to the surface of the bell and are wiped off by the oral arms ; ciliary currents carry the food into the mouth and distribute it for digestion in the various canals. Eight sense organs, the *rhopalia*, are arranged at the rim of the bell : each consists of a modified tentacle loaded with chalky crystals, which enables the animal to determine its posture in the water, and a very simple eye. A net of nerve cells underlies the epidermis. Jellyfish swim by contracting muscles on the underside of the bell, forcing water out of the bell so as to effect a jet-propulsion. This serves to keep the animal afloat but not to propel it against a current. Jellyfish form therefore a part of that population of floating animals, the *plankton*, which drifts in the sea at the mercy of its currents. Some jellyfish are more active than *Aurelia*, can swim more strongly, and catch food such as fish ; these usually have also more highly developed sense-organs.

The adult *Aurelia* is either male or female ; the gonads lie on the lower wall of the gut cavity. Below the gonads are small pockets, each with an opening on the lower surface of the bell within the purple ring but these have no connection with the gonads. Eggs are shed into the gut cavity when ripe, and are fertilized by sperms taken in by the feeding currents. After fertilization the eggs are caught up by the fleshy arms surrounding the mouth, where, in minute pouches, they undergo the early stages of development to a planula, clothed with cilia.

This leaves the shelter its parent affords, to lead a brief free-swimming life ; the larva soon sinks to the bottom, where it settles down, developing into a small polyp with sixteen tentacles, called a *scyphistoma.*

A peculiar series of events, called *strobilisation,* follows. The body of the scyphistoma becomes marked off by circular constrictions into numerous saucer-like disks or *strobili.* From each disk eight arms with double out-growths (*lappets*) arise. The strobili—or, as the larvae are now called, *ephyrae*—break off and swim away. The ephyrae are immature jellyfishes, which by later growths come to resemble their parents. A single polyp, or scyphistoma, thus gives rise to many future jellyfishes. The scyphozoan *Haliclystus* is a form which remains permanently attached like a scyphistoma, though it does not strobilate ; the young larva, however, does bud off some other planulae.

JELLYFISH. Mode of reproduction, from an early stage (top left) to the breaking-off of the strobili, as explained in this page.

Sea-Anemones

Those exquisite creatures called sea-anemones are polyps, and classified as Anthozoa ; one end of the cylindrical body serves as a region of attachment, while the opposite one bears the mouth and a circlet of fleshy tentacles. The outer surface of the body varies in appearance ; it may be smooth or grooved, and is often beset with wart-like growths or suckers. The plumose anemone (*Metridium*) is one of the most beautiful British forms. It has a translucent columnar body with deep frilled tentacular lobes resembling gorgeous pink and white plumes. *Tealia,* the dahlia anemone, encrusts its body with fine pebbles and shell fragments, so that it is effectively blended into the background on which it lives. This creature is a most voracious feeder, taking small shore crabs, barnacles, shrimps, other anemones, and even small fishes as food. *Adamsia* is a commensal form associated with a hermit crab (*Eupagurus*), being found on the whelk shell which forms the home of this crab. As the crab moves, the anemone trails behind and can pick up food particles dropped by the crab. The sting of the anemone is dangerous to other crabs, but not to this species of *Eupagurus.* If the crab has to change its whelk-shell for a larger one, it takes the anemone along too.

The hollow tentacles of anemones bear stinging cells resembling those of *Obelia,* which are used in defence and to capture prey. If adversely stimulated, or to prevent drying when the tide is out, anemones can contract right down and tuck the tentacles out of sight. The brightly-coloured blobs of jelly found in rock-pools are anemones which have thus protected themselves.

The mouth leads not into the gut cavity directly but into a short tube or gullet, which is lashed to the wall of the body by radiating vertical partitions, or mesenteries, which partially subdivide the digestive cavity into chambers. A small pore in the upper part of each mesentery places adjacent cavities in connexion with one another. In some species the lower free edge of each mesentery is drawn out into a long filament, or *acontium,* covered in mematocysts. These filaments can be protruded through the mouth or through pores in the body-wall, and assist the tentacles in killing the prey. They will also be protruded if the animal is irritated.

Anemones reproduce sexually, forming ciliated larvae which may remain for a time within the body cavity of the parent. Owing to their extraordinary powers of regeneration, they are also able to reproduce asexually. *Metridium,* for instance, practises the latter method ; the animal can move slowly by the muscular action of its base, or foot, and as it does so actually tears off fragments of its body. These fragments are able to reconstitute themselves into small but complete anemones.

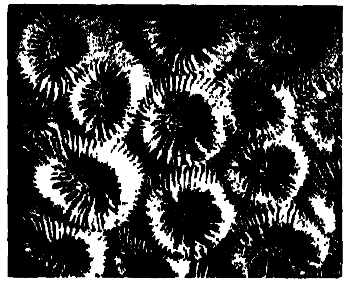
The Animals called Corals

The sea-anemones belong to a group of the Anthozoa characterised by possessing six, or a multiple of six, tentacles, and so do some of the animals called corals. Other corals belong to a second group of Anthozoa, which have always eight tentacles, which are pinnate, or bearing small side-branches. " Coral " is a term with no very precise meaning, applied to a number of coelenterates which form a massive limy skeleton ; even some of the Hydrozoa do this.

Coral Forms

The corals which resemble anemones may, like the anemones, be solitary, but sit upon a cup-shaped skeleton, which they secrete beneath the body ; such a form is the Devonshire

cup-coral, *Caryophyllia smithi.* Related forms are colonial, with many delicate polyps whose bodies are in continuity, secreting a common skeleton which may be a massive boulder. A portion of the skeleton of a daisy coral is shown in the photograph here, about natural size; in this form the polyps, which sit upon one of the cups shown, have each a mouth surrounded by a circlet of tentacles. In the brain corals the polyp individuals are not distinguishable, and rows of mouths are flanked by rows of tentacles; instead of having separate cups, the skeleton has many winding valleys with ridges between. The most successful modern reef building coral, *Acropora* (or *Madrepora*), has polyps smaller than those of the daisy coral illustrated, and forms large branching colonies.



DAISY CORAL SKELETON. Showing the cups in which the polyps lived.
British Museum of Natural History

Living Reefs

All the true reef-builders among corals contain (as do a number of other animals), unicellular plants within their tissues; apparently they do not feed upon these plants, being carnivores and catching small planktonic animals as food, and it is not clear what the plants do. Their presence, however, does seem correlated with the ability to form very great quantities of limy skeletons, for those corals which do not have symbiotic plants do not build such massive skeletons. (Symbionts are organisms of different species which habitually live together to their mutual advantage.) The need of the symbiotic algae for light restricts the corals to shallow water; living reefs are not found below 25 fathoms. The corals need high temperatures to breed, and so reefs are restricted to warm seas.

The precious red coral, *Corallium*, is a member of the other group of Anthozoa, with eight tentacles. It also is colonial, with small polyps covering a limy skeleton, but here the skeleton is internal, formed of a hard mass of spicules, within the body. The organ pipe coral, *Tubipora*, is a similar form with the polyps arranged side by side. The "dead man's fingers," *Alcyonium*, of British coasts, is a related type with the spicules of the skeleton not compacted. The sea-fans, *Gorgonia*, and the sea-pens, *Pennatula*, are also members of this group.

The last group of Coelenterata, namely, the Ctenophora, or sea-gooseberries, are delicate iridescent globes of "jelly" which live floating in the sea. The name ctenophore comes from two Greek words meaning "comb-bearing," and has reference to the characteristic structural feature of these animals—fine swimming plates arranged in eight rows or meridians on the surface of the body. These combs are groups of modified cilia and serve to propel the animal through the water, mouth foremost. The iridescence on the surface of the swimming animal is due to the movements of these rows of cilia as they catch the light.

Pleurobrachia, a common British form, has two tentacles of great length which trail away behind as the animal rows itself along, but which, when occasion demands, can be drawn into shallow pits at the sides of the body. Within the surface layer of the tentacles lie peculiar cells, called *lasso cells*, which contain

A GROUP OF COELENTERATES. Bottom, left to right: four plumose anemones (Metridium); two green jellyfish (Haliclystus); two sea-dahlias (Tealia) capturing prawns; Sertularia, a sea-fern; and Gorgonia, a sea-fan. Top, left: a milky blue jellyfish (Aurelia); on the right, two sea-gooseberries (Pleurobrachia), one of which has just caught a young pipe-fish.
Reproduced from a drawing by L. R. Brightwell in "Science of Life," by Wells, Huxley, and Wells

long adhesive threads and a central contractile fibril. The threads can be shot out and they stick to the prey, which is drawn towards the mouth by contraction of the tentacles. In this way the sea-gooseberry can easily capture small fishes and other creatures.

Another ctenophore, *Beroe*, is worthy of mention on account of the enchanting phosphorescence it produces in the sea at night. Perhaps the most remarkable form is *Cestus*, which, on account of its delicate ribbon-like body, some four or five feet in length, is called Venus's girdle. It is violet in colour, and common in the Mediterranean and other warm seas.

The coelenterates are an ancient group, traces of fossil jellyfish being found in Cambrian rocks, while throughout the Palaeozoic massive coral reefs were formed ; these fossils, however, are not of forms living to-day. Though the coelenterates are fairly simple in construction as compared with other Metazoa, there is no obligation to consider them as ancestral to other groups, nor to regard coelenterates living to-day as being "primitive." They are a successful group of animals which have exploited a simple mode of life.

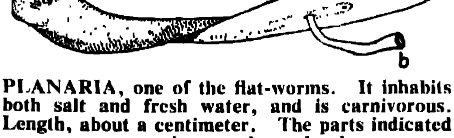
LESSON 9

Worms and Flukes

The body of a coelenterate is essentially a hollow sac with a central cavity open to the exterior by a single aperture. The walls of the sac consist of two layers of cells—epidermis on the outside and gastrodermis on the inside—with a layer of homogeneous jelly, the mesogloea, interposed. These layers are derived from an outer *ectoderm* and an inner *endoderm* of the embryo. In all other phyla of Metazoa there is, in addition to these layers, a third cellular layer in the embryo, the mesoderm. It might be mentioned here, perhaps, that every three-layered, or triploblastic, animal passes through a stage in development—the *gastrula* stage—when it has only ectoderm and endoderm. The mesoderm differentiates later. It is from the mesoderm that our own muscles, skeleton, heart and blood vessels, kidneys, and reproductive organs develop.

Flat-Worms

These are members of the phylum Platyhelminthes. They are elongated animals with a definite front and hinder end, and with right and left sides, or are *bilaterally symmetrical*, and their bodies are not divided up into separate compartments (*segments*), as are those of other worms mentioned later. In many instances they are parasites with complicated life histories. There are three groups of such creatures : (1) planarian worms (Turbellaria), (2) flukes (Trematoda), and (3) tapeworms (Cestoda). Planarians are found abundantly in both salt and fresh water and some of them occur even in damp earth. The skin is soft and covered with closely set cilia, by means of which they are able to move with a characteristic gliding motion. These animals are carnivorous in habit and possess a long, muscular pharynx (the first part of the food canal), which can be protruded considerably from the mouth. The mouth is not necessarily at the front end.



PLANARIA, one of the flat-worms. It inhabits both salt and fresh water, and is carnivorous. Length, about a centimeter. The parts indicated are : a, eye ; b, mouth and pharynx ; c, reproductive pore.

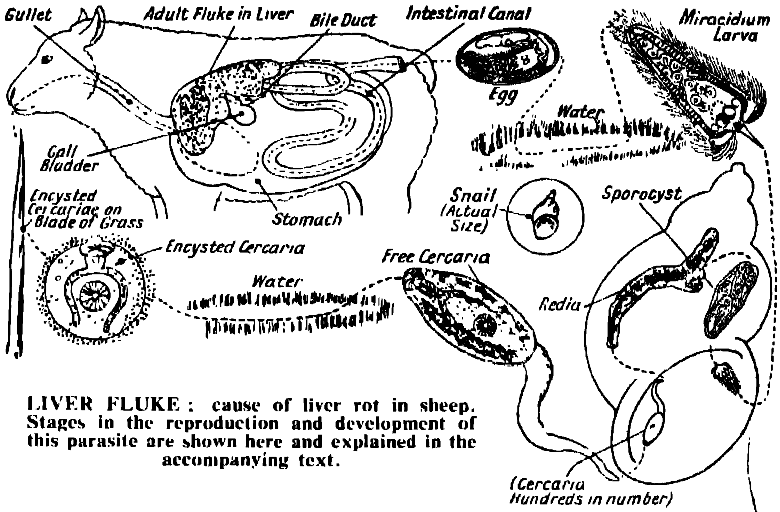
Liver Fluke

The fluke group (Trematoda) is closely allied to the Turbellaria, but the animals included in it have become greatly specialised in relation to parastic habit. The covering of cilia has been lost, while suckers and other organs of attachment have been developed. As an example : the liver fluke (*Fasciola hepatica*), the cause of liver rot in sheep.

The adult liver fluke lives chiefly in large channels leading out of the liver (bile-ducts) of the sheep. It is flat and leaf-like and about an inch in length. Near one end of the body is a small projection, at the top of which the mouth is found in the centre of a small sucker. A second sucker lies on the lower surface of the body, some little way back from the mouth. Food blood and disintegrated liver cells—is drawn into a tube within the body, the alimentary canal, which bifurcates and ends blindly. Such food materials are taken in by the action of the pharynx, a kind of suction pump, and are passed on to the alimentary canal.

Within the body are numerous multi-cellular organs of a complex nature, which carry out various functions. A paired system of delicate tubules associated with peculiar flagellated cells serves to remove waste fluids from the body by a single pore near the hind end of the animal. Nerve cells with processes bound together into fine nerves, which encircle the pharynx and ramify in the tissues, form a system by means of which the animal organizes its activities in accordance with events taking place in the world

around it. A very complex set of generative organs is also found within the body, for the animal is hermaphrodite, that is, both male and female in one. The various organs of the body are bound together by cells and fibres, which make up what is called connective tissue—here of a special kind—so that there is no continuous space within the body.



LIVER FLUKE: cause of liver rot in sheep. Stages in the reproduction and development of this parasite are shown here and explained in the accompanying text.

Reproduction in flukes is of great importance, because during multiplication infection of healthy animals occurs. Very large numbers of eggs are produced by the liver fluke, the gall bladder of a single sheep infested with 200 parasites having altogether nearly ten million eggs. Parasites of all kinds are notoriously fertile, with complex life histories, because the chances of survival are so slender that if this were not the case they would soon become extinct. The eggs of the fluke ultimately pass out of the body of the sheep, and if this takes place on damp ground there is a reasonable chance of their survival. The most favourable conditions are afforded by low-lying pastures liable at times to be flooded. Then there hatches out from the egg a minute, conical, ciliated larva, or *miracidium*, which swims about in search of a small species of water snail (*Limnaea truncatula*), but soon perishes if unsuccessful. The successful larva bores its way into the soft tissues of the snail and comes to rest in the lung chamber. There it appears to degenerate, becoming changed in appearance to form an irregular sac, the *sporocyst*. Degeneration is apparent, not real, for within the sporocyst certain cells develop exactly as would fertilized eggs. Since they are not eggs, this is an example of *parthenogenesis*, or virgin birth, and it leads to the production of representatives of the next stage in development, *rediae*.

In a Sheep's Stomach

During a single summer several generations of rediae arise by budding one within the body of another—recalling those peculiar Chinese puzzle boxes. Later in the season one set of rediae (the last generation) produce within their bodies a later stage, *cercariae*, minute tailed tadpole-like larvae. These desert the snail, swim to the stems of water plants or blades of grass, and pass into a quiescent stage or encystment, when they are covered each by a limy coat. If a sheep crops the herbage to which the cysts are attached, the limy coats are dissolved in the mammal's stomach and the young flukes pass on to the intestines and make their way up the bile duct towards the liver, where they become mature flukes. A sheep can tolerate a few flukes without suffering in health, but if the parasites are present in large numbers the results are dangerous and may be fatal.

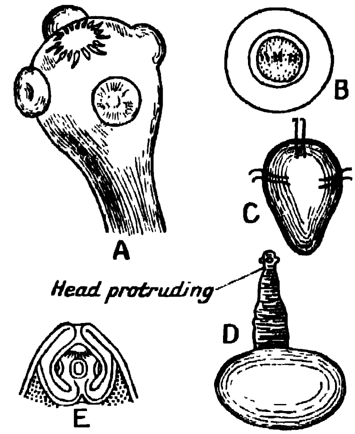
Tapeworms

These baneful creatures are all internal parasites, the characters of some of the simpler ones suggesting that they have descended from fluke-like ancestors by further modification. Digestive organs, in the ordinary sense, are lacking—for these animals live surrounded by liquid nutriment in the partially digested food or in the blood and other tissues of their hosts. This readily available food is absorbed through the soft covering of the entire body.

One of the best-known members of the Cestoda is the common tapeworm (*Taenia solium*) which lives its adult, sexually-mature life in the intestine of man. At one end of the animal is a minute head, or *scolex*, which holds on by hooks and suckers to the lining of the intestine. Behind this are numerous (nearly a thousand) flattened joints or *proglottides*, of which the largest and most mature are those farthest from the scolex. The proglottides are constantly being formed during the life of the worm by a process of budding in the region just behind the scolex. Each proglottis contains a set of complex male and female reproductive organs.

Ripe proglottides crowded with eggs pass out of the body of the host in chains, and when the proglottis decays, the eggs are liberated. Eggs which chance to be swallowed by a suitable warm-blooded quadruped, especially the pig,

develop further. A minute spherical embryo with six little hooks hatches out and burrows through the wall of the food canal, gets into the blood stream and is carried to the muscles. Here it passes into a quiescent stage (*cysticercus*), as a minute bladderworm, in which it may remain indefinitely — for no further development takes place in the body of the pig. But the pig when killed yields " measly" pork, the encysted bladderworms giving its muscles (the meat) a spotted appearance.



TAPEWORM. A, head of *Taenia solium* showing suckers and ring of hooklets. B, egg. C, embryo. D, developed cyst of *T. solium*. E, partly evaginated scolex of *T. saginata*.

The bladderworm is a hollow sphere, the wall of which is pushed in at one point. This intucking is gradually converted into a tapeworm head, hollow and inside out. Should a human being eat measly pork insufficiently cooked, the tapeworm head of the bladderworm is everted and becomes solid, while the bladder itself is resorbed. The head attaches itself to the lining of the small intestine, the chain of proglittides is budded off from it, and in this way the adult stage is in due course reached, completing the reproductive cycle of the creature.

Internal Budding

The bladderworm stage in development of some tapeworms may be a source of danger to the host. Perhaps the most dangerous form of this kind is *Taenia echinococcus* ; the bladder may contain up to a gallon of fluid and by successive internal budding develops large numbers of new scolices. The adult of this form is less than a quarter of an inch in length and has only three proglottides. It infests the intestine of dog, wolf, and jackal. Another multiplying cysticercus is *Taenia coenurus*, which establishes itself in the brain of the sheep and causes the condition known as staggers. The adult lives in the intestine of the dog, so that the shepherd's dog may be a source of infection of the flock.

Round-worms

In considering these creatures we pass to another phylum, the Nematoda. The body is usually long and cylindrical with pointed ends and, like most creatures which live in the dark, the members of this phylum are white or yellowish. The surface is smooth and covered with a glistening cuticle, which protects the animal from the digestive juices of its hosts. There are no definite locomotor organs, and the animal progresses by wriggling movements. A long, straight, alimentary canal traverses the animal, enclosed in a space within the body. The space is filled with fluid and wandering cells : it also houses the reproductive organs, its walls bearing long excretory tubules and fine nerves. Nematodes are bisexual, that is, male or female, and the male is usually smaller than the female and has a curved tail.

Dangerous to Man

A well-known genus is *Ascaris*, which infests horses and human beings without causing the host any serious inconvenience, but some members of the phylum produce most dangerous disorders. Some forms are free-living and others are commonly found in plants, where they may be either harmless or destructive.

The female of the guinea worm (*Filaria medinensis*) lives under the human skin in tropical Africa, setting up abscesses. Its slender body is several feet in length. A minute related species, *Filaria bancrofti*, lives in the lymphatics of man, the adult forms being the cause of elephantiasis, that strange tropical disease in which the members of the body swell to enormous proportions. The young larvae swarm into the blood at night and disappear into the tissues during the day. This form is distributed by mosquitoes, which feed only at night. A round-worm dangerous to man is *Trichinella spiralis*. This is a minute form—less than one-tenth of an inch long—which infests the rat ; if this should be eaten by the pig (as it often is), the young worms bore through the wall of the stomach and work their way in the blood to the muscles, there to encyst. Infested pork, improperly cooked, is the source of human infection, resulting in serious illness or death.

A most curious feature of these animals is that though departures from the *Ascaris* plan of structure are not great, life histories are subject to tremendous variation. Species other than those mentioned cause a wide range of diseases: one form, *Syngamus*, causes the disease known as gapes in chickens ; *Tylenchus* infects wheat, so that a brown gall is produced instead of a grain ; *Heterodera* is a parasite of the roots of tomatoes and cucumbers ; *Sphaerularia* is a parasite of the humble-bee, and causes its host to emerge from the nest too early in the year. There is perhaps no other phylum showing such ubiquity as the Nematoda.

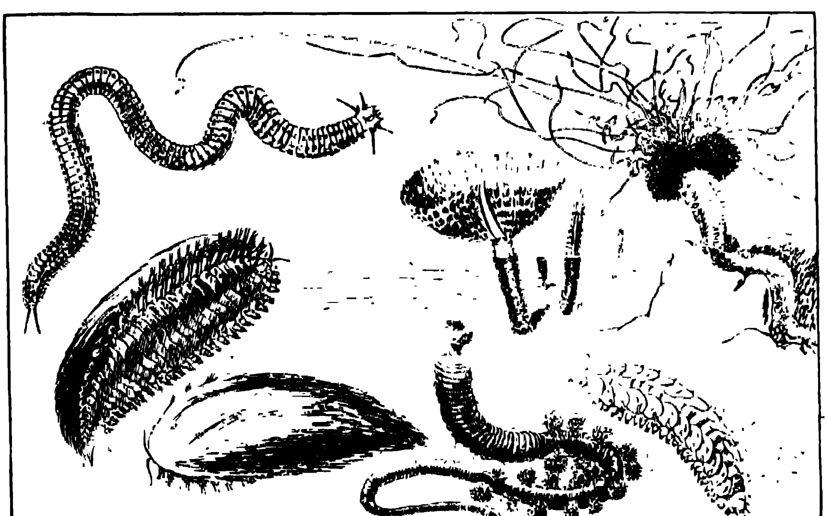
LESSON 10

Earthworms and their Aquatic Kindred

EARTHWORMS, lugworms, and leeches belong to the phylum Annelida, which includes all animals commonly known as ringed worms—soft-bodied creatures of elongated form divided up into a number of external rings (and internal compartments) or *segments*. The segments are much alike, on the whole, though there is sometimes a well-defined head region. The body has a soft covering, and is never armoured like the bodies of those other segmented invertebrates, the Arthropoda. Annelids differ from these jointed-limbed creatures in another respect ; the blood is confined to definite channels, or *vessels*, instead of lying in a continuous space within the body. The blood of ringed worms, moreover, often contains a red colouring substance like our own, though it may be colourless, pink, or green, in some types. It is never blue, however, like the blood of Arthropoda.

Within the annelid body is a large space, broken up only by the *septa*, or partitions between the segments. This cavity, the *coelom*, contains various important organs, and marks a definite advance beyond any type of structure we have so far examined ; it is a cavity which occurs also in vertebrate animals. The bodily organs are a network of blood vessels, excretory and reproductive organs, digestive organs, and a rudimentary brain, together with fine nerves. The digestive organs consist of a straight tube, the alimentary canal, which extends from the mouth at one end of the animal to the anus at the other. In addition, there are a number of glands associated with the canal which secrete fluids that have a digestive action on food. In the annelids, and in all the phyla to be considered later, with a few minor exceptions, all stages of digestion take place in the lumen of the gut, and only the products of complete digestion are absorbed by the cells of the gut lining. This is in contrast with the coelenterates and members of certain minor phyla. The excretory organs are essentially tubes of ectoderm cells, which project inwards into the coelom. Such organs, or *nephridia* as they are called, are metamerically repeated (that is, one pair is found in each segment) except in the head region and near the hinder end of the animal. Other organs also show this metamerism, the nervous system particularly, there being a paired cluster of nerve cells (*ganglion*) in each segment, successive ganglia being connected with one another by paired strands containing nerve fibres. From this chain of ganglia, which lies towards the lower surface of the animal, small nerves pass to the surface of the lower organs, muscles, and sense organs (eyes, tentacles, etc.) of the body.

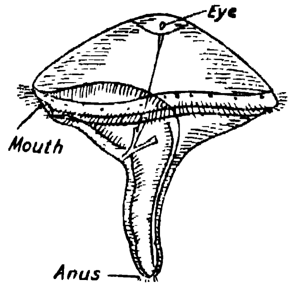
The three important groups of annelids are the bristle-worms (class Polychaeta) the earthworms and their fresh-water relations (Oligochaeta), and the leeches (Hirudinea). The first includes a host of marine worms which live in sand or crevices—sometimes in tubes of their own making, as in the accompanying illustration. These, and the earthworms, are characterised by small bundles of bristles (*setae*) which grow out from the segments, and which give the animal a hold on the underlying surface and prevent slipping. The bristles occur on conical bilobed, but unjointed foot-



MARINE WORMS. Lower, left to right : Two sea-mice (Aphrodite) : a burrowing lugworm (Arenicola) with its tufted gills : and a scale-worm (Lepidonotus). Top : A rag-worm (Nereis) : and tube-building worms (Sabella and Amphitrite), spreading their tentacles for oxygen and food.

Reproduced from a drawing by L. R. Brightwell in "Science of Life," by Wells, Huxley, and Wells

stumps, or *parapodia*, at the sides of the body in polychaetes, though not in oligochaetes. The Hirudinea are adapted for a specialised mode of life—they are predatory on animals larger than themselves, sucking blood or soft tissues—and their entire organization is affected by it. Bristles have been lost, and suckers developed, better adapted for clinging to the skin of another animal ; and the body has become shortened.



BRISTLE-WORM. Side view of larva or trochosphere.
From Parker & Haswell, 'Zoolo, Macmillan

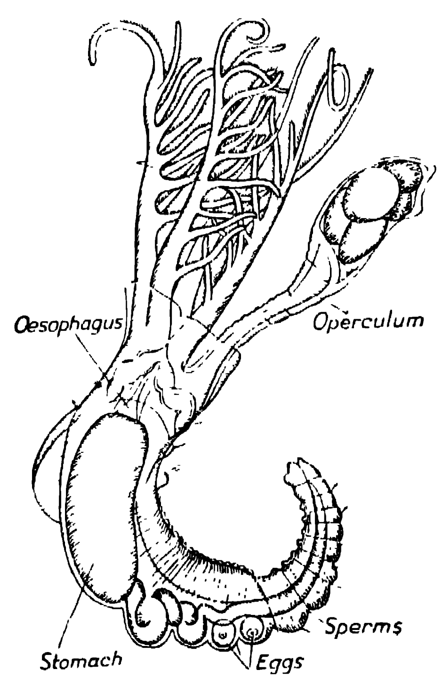
Bristle-worms

The characters of polychaetes are best understood by examining one of the common shore forms, *Nereis*, the rag-worm. Here are seen the general characters already mentioned, including a definite head, which bears feelers of two or three kinds and four simple eyes. This animal, like many of its allies, is carnivorous, and seizes its prey by means of a pair of horny jaws borne on the pharynx lining, which also possesses a number of small hooks. This is achieved by everting the pharynx and thrusting it out from the mouth. The bristles of *Nereis* are short, but in some forms they are long and sharp, serving as an excellent means of defence. In one kind of sea-mouse (*Aphrodite*) they are beautifully iridescent. In some of the swimming bristle-worms, the parapodia which carry the bristles have become broadened out into serviceable paddles. This happens also in the hinder part of the body of forms like the palolo-worm (*Eunice viridis*)—which live in rock crevices and coral growth—at breeding time. On two days in the year—and uncannily true to the day—the worm creeps out of its crevice and the modified hinder part of the body, containing the eggs or sperms, breaks off and wriggles to the surface of the sea, while the head end of the worm creeps back into its shelter. The swimming hind parts of numerous animals swarm at the surface for the nuptials, dying off after the eggs have been fertilized. The eggs develop into peculiar microscopic larvae called *trochospheres*, which live at the sea surface and are totally unlike the parent.

Some bristle-worms have taken to a comparatively sluggish burrowing life, as in the case of the lugworm (*Arenicola*)—much esteemed as bait by sea anglers, and also known as lob-worm—which swallows sand or mud for the sake of nutritious matter covering the grains. A sticky fluid oozes from the skin of the worm and glues the surrounding mud or sand into an ill-defined temporary tube. Many bristle-worms however, have taken to a permanently fixed mode of life, and these construct firm tubes of various kinds and shapes. They may be of horny texture, built of sand grains and fragments of shells, or calcareous. In *Serpula*, which lives in a limy tube, the parapodia are reduced, but some of the feelers of the head have been converted into elegant branched plumes. They are beset with cilia, which by their movements set up currents that carry small animals and other nutritious particles to the mouth. The plumes, however, serve as breathing organs, in which the blood receives the oxygen dissolved in sea water. Below the plumes is a collar, which is concerned with making the limy tube.

The sinuous calcareous homes of *Serpula* are commonly seen upon shells and stones. If undisturbed, the animal gradually extends its plumed head, retracting it in the twinkling of an eye if danger threatens. The tube is then sealed by a conical stopper, formed by modification of a feeler. The minute dwelling of another common type, *Spirorbis*, is especially abundant on brown seaweeds ; and here the peculiar "operculum" is hollowed out to serve as a pouch within which the eggs pass through their early stages of development.

One of the most peculiar and interesting of



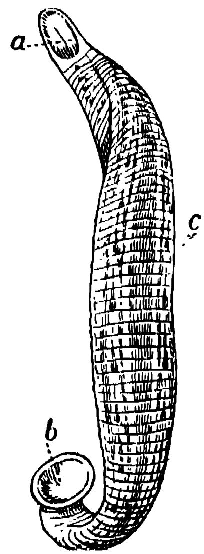
SPIRORBIS LAEVIS, a hermaphrodite, tubed marine worm, with developing embryos in the operculum.
Reproduced by permission from Parker & Haswell, "Textbook of Zoology," Macmillan

tubed worms is *Chaetopterus*, the parchment-tube worm. It lives in a self-made tube fixed to stones and partially buried in the sea-floor. It has a funnel-shaped head with two tentacles and eyes. Behind the head are nine segments bearing parapodia with strong bristles. The tenth segment carries two wing-like lobes provided with ciliated grooves. During life (and the animal will live comfortably in a glass tube so that its movements can be watched) food particles pass along these grooves to a cup-like organ some little way farther back, where they are rolled up into minute balls. They are then passed back, but this time to the mouth. The water current through the tube is produced by the incessant sweeping of three pairs of fans still farther back, and below these are small suckers by means of which the animal can anchor itself within its tube. The polychaetes are known as fossils since the Cambrian, many forms even more elaborate than the modern ones being found in rocks of that age.

Earthworms

Profoundly modified in adaptation to the burrowing habit are the earthworms. The pointed end of the animal—one can scarcely speak of a head—is devoid of feelers and eyes, and the pharynx is not eversible like that of the rag-worm. The parapodia are represented only by rows of bristles; these are minute but can be felt if the finger is passed along the body from the hinder end to the front end. There are no jaws, but the pharynx is exceedingly muscular and acts as a kind of pump for taking in food. This consists of earth, containing animal and plant remains. The worm possesses a muscular gizzard, or grinding-mill. As Darwin long since demonstrated, the earthworm is one of the farmer's best friends, for its burrows drain and aerate the soil. Moreover, the earth which has passed through its digestive tube is extremely finely divided and has been brought from low levels. The activities of the animal effect a turning over of the soil layers.

The earthworm is hermaphrodite, but does not fertilize itself. Instead, two individuals come into a close union and exchange male reproductive elements. These are stored in special receptacles within the body until required, that is, when the eggs are ripe. At this time the animal produces, from a thickened region of the body some little distance from the front end, a fluid which sets in the form of an elastic ring. The animal wriggles backwards out of the ring, which closes to form a tiny capsule. During the process of wriggling, eggs are deposited in the capsule, and sperms, derived from another animal, are shed over them. Closure of the capsule is followed by fertilization, and development ensues in the shelter of the cocoon. A common aquatic Oligochaete is *Tubifex*, a small red worm living in mud at the bottom of ponds.



HIRUDO MEDICINALIS, the common leech. a, mouth; b, hind sucker; c, sensory papillae on first annulus of each segment. The remaining four annuli which make up each true segment are indicated by markings on the upper surface.
Shipley & MacBride, "Zoology," C.U.P.

Leeches

These animals live in the sea, in fresh water, or even in damp tropical forests away from sheets of water. Their organization can be understood by studying the medicinal leech, *Hirudo medicinalis*, a fresh-water species occurring in British ponds and streams. A most remarkable feature about the bodies of leeches is the constancy in the number of segments. There are always 32 segments, together with a shelf-like process overhanging the mouth. This and the first two segments form the anterior sucker, while the last seven segments form the posterior sucker. The segments are externally broken up into secondary rings of variable number. In the medicinal leech there are five annuli to each true segment.

Externally, leeches are recognized by the suckers at each end of the body—the chief locomotor organs. Parapodia and bristles are lacking. Movement is effected by holding on to a substratum with one sucker and expanding the body, then fixing with the remaining sucker while the first is relaxed, and shortening the body. Alternate shortening and elongating of the body is brought about by the contraction of continuous circular and longitudinal muscles in the body wall. This looping movement is not the only one possible, however, for the animal can swim efficiently by undulatory movements of the body. The mouth is in the middle of the front sucker, which serves to fix the leech to its temporary host or its prey. Three saw-edged blades are then brought into play, a three-rayed cut being made; and a peculiar secretion, which prevents blood from clotting, is poured into the wound. Since the animal may need to subsist for long periods between meals, there is a large dilatation of the digestive tube in which food can be stored.

Like the earthworm, the leech lays its eggs in cocoons, formed in a similar manner. Some leeches further resemble the earthworm in

having a well-developed *coelom* (body-cavity) with *septa* (partitions) forming the segmental boundaries; but in most leeches this cavity tends to disappear, being filled with a great growth of tissue until it is reduced to a few narrow channels. Another point of resemblance to the earthworm is the hermaphroditism of the leech. But fertilization is vastly different. It appears that the leech deposits sperms in small bundles on the outer surface of the body of another individual. The sperms then penetrate the skin and make their way to the *ovaries* (egg-producing organs), where fertilization occurs before the eggs are laid in the cocoons.

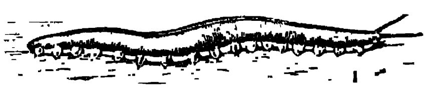
LESSON 11

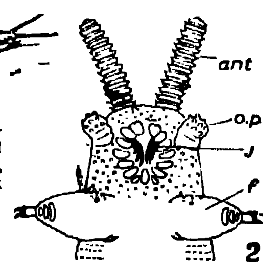
A First Lesson on the Arthropods

The phylum Arthropoda contains more species, and probably also greater numbers of individuals, than any other phylum; the insects alone account for over two-thirds of all the species of living animals described. Because it is so large, the phylum is divided, for convenience, into sub-phyla, as follows. The Insecta are the most successful terrestrial forms; also land-living are the Myriapoda (centipedes and millipedes), and the spiders and mites. The two latter groups, with some aquatic relatives, form the Arachnida. Mainly aquatic are the Crustacea, the crabs and barnacles and water-fleas. There is also a small group, the Onychophora, which is included here, though it is not certain that it should not rather go into the Annelida.

Arthropod Affinities

The animals included in the phylum Anthropods have much in common with the Annelida, and must have been derived from the same stock. The body is divided up into a series of rings, or segments, which are of limited number and considerably fewer than in worms.





RUDIMENTARY ARTHROPOD. Fig. 1 (above). General view of Peripatus. Fig. 2 (right). Lower aspect of front end; ant., pre-antenna; o.p., oval papilla; j, jaw; f, first trunk appendage.

The body is enclosed in a thick cuticle, and the thickness of this armour has necessitated the development of flexible joints between the segments. In addition, instead of the continuous muscle layers of the worm's body wall, systems of separate muscles move the parts of the body. The jointed legs give the phylum its name.

In the arthropod there is no distinction between the body cavity and the blood vascular system, the former being derived from greatly dilated blood channels. After the early stages of development the true coelom, such as occurs in annelids, is found solely in the hollow sac-like reproductive organs, its main part having vanished.

Development of Peripatus

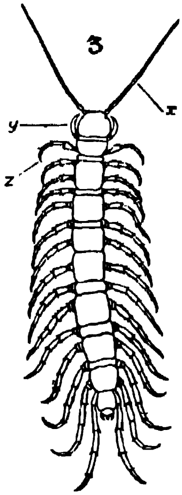
Peripatus, the sole representative of the Onychophora, occurs as several species with a very wide distribution through the hotter parts of the globe, being represented in South America, the West Indies, South Africa, the Malay peninsula, Australia, and New Zealand. It lives in rotten tree-stumps and other damp places, and on cursory examination resembles a caterpillar. The body, though not clearly divided into rings or segments, bears numerous pairs of conical legs, which are not divided into proper joints and which carry each a pair of sharp claws at the tip. The mouth is on the underside of the head and is provided with a single pair of jaws, formed by modification of a pair of legs. The jaws of arthropods in general are not, as in backboned animals, part of the head framework but modifications of the jointed limbs typically borne in pairs by the segments. The bite is from side to side, while the jaw of a backboned animal is moved up and down.

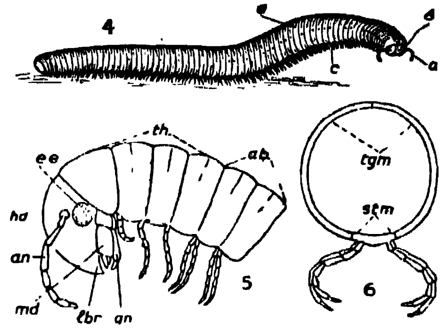
A second pair of limbs in the head region have given up the locomotor function and form blunt projections upon which peculiar slime-secreting glands open. The slime can be ejected to some distance, serving to secure small insects as food, and also as a means of protection. Also on the head are two feelers or antennae; these are sensory organs. Near the base of each antenna is a small, ill-formed eye, which is built on a simple plan and resembles the eye of a worm rather than the compound faceted eye of an arthropod. The body cavity consists of a number of irregular spaces containing blood, and no internal segmentation is apparent. The heart is an elongated tube perforated by openings, or *ostia*. The sexes among members of this genus *Peripatus* are separate, the reproductive organs paired. In almost every segment of the body there is

a pair of excretory organs, coiled tubes, or nephridia, which open by funnels clothed with cilia internally and by small pores at the bases of the legs externally. Similar organs are found characteristically in the annelid.

A study of the development of the genus *Peripatus* is of importance because researches have shown that the embryo develops a true segmented coelom exactly as does an embryo worm, but that this cavity does not realize its full potentialities and is represented in the adult solely by the cavities of the reproductive organs and the segmentally arranged nephridia.

The true classification of *Peripatus* is puzzling. It has been thought to represent a form intermediate between the Annelida and Arthropoda, because though in many characters it resembles the worms, it has lost a coelom, and also breathes by means of little tubes, the *tracheae*, which convey air to the tissues, a method also adopted by the insects. These peculiarities, however, might have been acquired independently of the arthropods. In certain Cambrian rocks of Canada, the same rocks which contain the Polychaete fossils mentioned earlier, are found one or two animals which in outline resemble *Peripatus* very closely, though they would have lived in the sea. True arthropods are also found here. The Onychophora are sufficiently similar to the annelids and the arthropods to have been derived from the same common stock, but the *Peripatus* living to-day cannot itself be regarded as a true connecting link between the two phyla. It represents rather an unsuccessful attempt at terrestrial life on the part of an ancient, primarily aquatic group, and is confined to damp environments because it has not solved the problem of preventing its own drying up owing to the evaporation of water from the body in dry air.





MYRIAPODA. Fig. 3, Lithobius, a British centipede, upper view; x, antenna; y, maxilliped; z, pair of walking legs. Fig. 4, Julus terrestris, a millipede; a, antenna; b, eyes; c, legs; d, pores for escape of excretion of stink glands. Fig. 5, Side view of front end of J. terrestris; an., antenna; ab., abdomen; e.e., clump of ocelli; gn., modified jaw; hd., head; lbr., labrum; md., mandible; th., thorax. Fig. 6, Segment of J. terrestris detached from the rest; stm., sternum; tgm., tergum.

Centipedes

The animals included in the sub-phylum Myriapoda are air-breathing arthropods which, unlike *Peripatus*, have successfully solved the problem of becoming land animals, though not so successfully as have the insects. It is true they live in soil, which is a damp environment, but they are almost everywhere common whereas *Peripatus* is rare.

There is a stiff armour of cuticle. The body is clearly divided into segments, the limbs are distinctly jointed, and three pairs of them have become converted into jaws. A pair of fairly long antennae and two groups of simple eyes are on the head. A system of tracheae or air-tubes is well developed and each air-tube has a spiral thickening in its lining, so that its walls are prevented from collapsing. The openings of these tubes, the stigmata, lie on either side of the body. The two types of Myriapoda, centipedes and millipedes, show well-marked differences in structure and habit. Centipedes are exceedingly active creatures of carnivorous habit. They are flattened from above downwards, and each segment of the trunk bears one pair of jointed limbs, while every other one is perforated by a pair of stigmata. The two legs next to the jaws have become converted into formidable poison claws, rendering some of the tropical species—like *Scolopendra*, which may attain a length of 8 inches—dangerous even to man. The commonest British form is *Lithobius*, a small and rather shortened form. *Geophilus*, another British centipede, is long and slender, and is said to be a relentless enemy of earthworms.

Millipedes

Millipedes are slow-moving myriapods of vegetarian habit, devoid of poison fangs and quite harmless. Their bodies are cylindrical and well segmented, but there is an important difference between the segmentation of millipedes and centipedes: in the millipedes each apparent segment is really the result of fusion of two adjacent segments, which explains why there are two pairs of limbs and two pairs of stigmata to each body-ring. Some British species—like *Julus*, which is common in hedgerows—curl up if alarmed; greatly shortened millipedes, like *Glomeris*, roll themselves up into a ball under similar conditions, looking then very like woodlice.

One would scarcely expect the creatures under

discussion to be capable of much parental solicitude, yet such is the case, at least as far as the mother is concerned. The small British centipede mentioned (*Lithobius*) covers the eggs with a sticky fluid, by means of which particles of earth are cemented around the eggs, serving to camouflage them. The small pellets thus formed are inconspicuous ; and there is need for this, since the father centipede is an egg-eating cannibal. Equally painstaking is the female of one of the British millipedes (*Julus*), though in this instance the male is not an egg-eater. She burrows into the ground and constructs a nest of earth about the size of a hazel nut, in which from 60 to 100 eggs are laid.

In centipedes and millipedes are examples of friends and foes of the farmer. The rounded, sluggish millipedes are vegetarian, and some of them—the so-called "false wireworms," for instance—attack the underground parts of various crops, and are thus pests of agriculture. The very active, flattened centipedes are carnivorous and attack and destroy numerous agricultural pests.

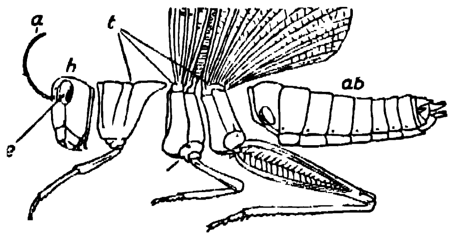
LESSON 12

Some Common Forms of Insect Life

The sub-phylum of Arthropoda called the Insecta includes more species than all other groups of animals together. Yet the animals in this sub-phylum are closely similar to one another. The general plan upon which the insect body is built renders insects clearly distinct from all other animal types. The body is short and made up of comparatively few segments, which form three well-marked regions. These are called head, thorax, and abdomen respectively.

The head of an insect comprises six segments not obvious in the adult—and bears a number of appendages. A pair of feelers, or antennae, and two large compound eyes (sometimes, in addition, several simple eyes) are in front ; three pairs of jaws, which differ greatly according to the habits of the insect, are in front and below. The thorax is composed of three segments, and it has three pairs of jointed legs and usually two pairs of wings. The abdomen generally consists of eleven segments, and is devoid of walking appendages.

The legs of an insect are made up of five sections, and in many instances end in a pair of claws embracing a cushion of soft tissue. Legs may be adapted to a variety of habits. *Dytiscus*, the giant water beetle, has legs modified for the purpose of swimming ; the grasshopper has jumping legs ; the cockroach has running legs ; the forelegs of the praying mantis are adapted for grasping prey. Limbs may assist in the production of characteristic sounds.



TYPICAL INSECT. Sketch of grasshopper to show external segmentation typical of insects ; ab., abdomen ; a, antenna ; e, eye ; h, head ; t, thorax.

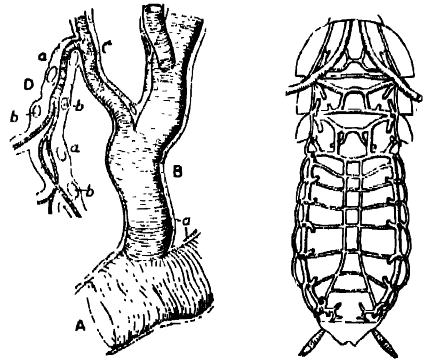
From Borradaile, Eastham, Potts and Saunders, "The Invertebrata," Cambridge University Press

The wings of insects are thin folds of skin horizontally flattened and arising from the soft joint between the armour plates on the upper and lower sides of the thorax. The space between the upper and lower layers contains a blood chamber into which the tracheal tubes grow. The veins—so conspicuous on the wings, and constituting the strengthening framework of these organs—are merely tough-walled spaces around the trachea, and during development of the wings, they carry blood, and nerve fibres.

Internal Organs

The tracheal system is exceedingly complex and opens to the exterior by small openings, or *stigmata*, on the soft membrane between the upper and lower armour plates ; two pairs of stigmata are in the thoracic region, eight pairs in the region of the abdomen. The tracheal tubes branch repeatedly, and the finest branches, or *tracheoles*, always end in the cells composing the body, never blindly in the blood ; oxygen is carried to the cells independently of the blood. This is in contrast to the method in all aquatic animals over a certain size, and all terrestrial animals other than arthropods, where oxygen must be carried from a respiratory surface to the tissues by the blood. Carbon dioxide is eliminated as fast as it accumulates, also by the tracheae. The nature of the respiratory mechanism also determines the small range of size within which all insects must remain. The laws of gaseous diffusion, upon which the conduction of gases to and from the tracheoles depends, break down just beyond the size limit of existing insects, so that this means of respiration is impossible in larger animals. Insects are thus of necessity small.

There is invariably a digestive canal, which, while short and straight in the larva, is often



TRACHEAL SYSTEM. Left, portion of trachea, A, of a caterpillar. B, C, and D, branches; a, cellular layer; b, nuclei. Right, principal trunks of the tracheal system of the cockroach.

From Parker & Haswell, "Textbook of Zoology," Macmillan

long and much coiled in the adult. It shows differentiation into three important regions, called fore-, mid-, and hind-gut respectively. These regions are further subdivided into smaller regions, each with a definite function. Salivary glands open into the fore-gut. The task of digestion and absorption of food materials is delegated to the mid-gut; the hind-gut is the tube through which indigestible residues pass to the exterior at the anus.

In the nature of its blood-vascular system the insect is a typical arthropod, for this system is a set of ill-defined spaces, the organs of the body being bathed with blood. There is a definite heart, however, which lies in the upper part of the body. It is an elongated tube of 13 chambers, each of which corresponds to a segment and has a pair of minute openings, or *ostia*, in its walls. Blood is propelled forwards in the heart, and passes into a fine vessel towards the head, whence it is forced into the blood spaces of the body.

The nervous system consists of a brain and a number of clusters of nerve cells, or *ganglia*, connected to form a chain by threads built up of nerve fibres. The brain lies on the upper side of the fore-gut; the nerve chain runs along the lower part of the body. The nervous system is responsible for the regulation of the movements of the body and co-ordination of impressions received from the world around.

Many characteristics are considered in classifying insects, the best-known ones having reference to the mouth parts, the wings, and the life history. With respect to this last, an insect—butterfly, for instance—may hatch out from the egg as a larva totally dissimilar from the adult, into which it is transformed by radical changes constituting a metamorphosis. Or, as in the cockroach, the young animal may resemble its parents from the first, becoming adult by slight changes, which are chiefly in size.

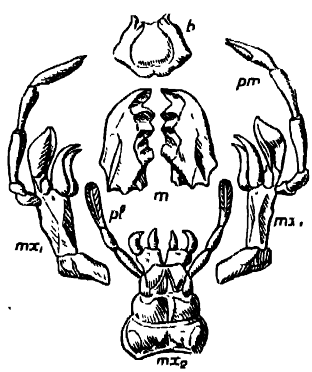
The arthropods, having a rigid exoskeleton, are not able to grow without casting the old cuticle and forming a new one of larger size. Such a process of moulting takes place between each two larval stages of insects, but, having reached the adult form, an insect ceases to grow; but some arthropods continue to moult and grow while adult.

Wingless Insects

Space limitation forbids dealing at length with the many kinds of insects known to entomology, and we must be content to glance briefly at some of the commoner forms. The Apterygota are wingless insects; this class of the Insecta does not include all insects devoid of wings—some of these belong to other groups, for the good reason that their ancestors possessed powers of flight—but only certain primitive forms representing an early wingless stage in the sub-phylum. The Apterygota include small insignificant creatures which lurk under stones or tree-bark, or live in other similarly sheltered places. Two insect types met with here are the bristle-tails (Thysanura) and the springtails (Collembola).

Bristle-tails are so named because of the jointed bristles at the hinder end of the body; a more interesting feature is the presence of projections on the abdomen which represent traces of limbs. There are reasons for supposing that insects have arisen from centipede-like creatures by a shortening of the body, the establishment of three regions, and the suppression of some of the posterior limbs. Bristle-tails come closest to the postulated ancestral type.

Springtails get their name from the "spring and catch" arrangement under the abdomen with its prongs projecting forwards and held in place by a minute projection. When liberated from its catch the fork is drawn forcibly back by muscular action, projecting the insect into the air.



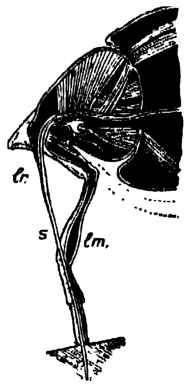
MOUTH PARTS OF COCKROACH. b, labrum; m, mandible; mx_1, first pair of maxillae; mx_2, second pair of maxillae; pl., labial palp; pm., maxillary palp.

Parker & Haswell

Orthoptera

Some members of the order Orthoptera are generalised and very suitable for study by those

who wish to grasp the complexities of insect structure. The cockroach, for instance, has a biting mouth, in relation to which three typical pairs of jaws are made out: (1) the hard-toothed first jaws (mandibles); (2) the second jaws (first maxillae) with a cutting blade and a feeler; (3) the third jaws (second maxillae) also possessing feelers and partly fused together into what is called the "lower lip," or *labium*. The so-called "upper lip," or *labrum*, is a plate overhanging the first jaws.



HEMIPTERA: MOUTH PARTS. Section through head of Graphosoma italicum; lm., labium; lr., labrum; s., stylets.
Borradaile

The forewings are modified into horny wingcovers, under which the delicate hind wings fold fanwise when not in use. The limbs vary in nature. The Orthoptera are divided into runners (Cursoria) and leapers (Saltatoria). In the former all three pairs of legs are alike; among the leapers the hind limbs are enlarged and serve as leaping organs.

Cockroaches, praying mantids, stick and leaf insects, are included in the Cursoria. The first of these—sometimes erroneously referred to as "beetles"—though emitting a disagreeable smell, are harmless. It is a common kitchen pest but not native to Britain. Praying mantids—rapacious creatures found in warmer parts of the world—derive their name from the fact that the front legs are turned up and serve to grasp prey, leading to a supplicatory attitude responsible for various superstitious ideas. Stick and leaf insects are vegetarians of warm climates; they resemble the objects after which they are named, in both colour and shape—a protective device.

Grasshoppers, Locusts, Crickets

The Saltatoria include grasshoppers, locusts, and crickets. The first of these have short antennae and possess organs of hearing in the base of the abdomen. The pleasing chirp of our field grasshopper is the love-call of the male, and is produced by rubbing a beaded ridge on the inner side of the thick part of the hind leg against the wing-cover. Locusts are notorious on account of the immense swarms in which they appear from time to time, with disastrous results to vegetation. Locusts are "short-horned" grasshoppers. Other grasshoppers have long antennae and are called "long-horned." Crickets differ in minor respects from other Saltatoria; there are jointed bristles projecting from the tip of the tail. The house-cricket is the best-known form; the burrowing mole-cricket is the most extraordinary one. The latter is a carnivore in which the forefeet, used as spades, have become gradually modified into that shape. Earwigs, which in some ways resemble the Orthoptera, are in a separate order, the Dermaptera.

Plant and Other Bugs

Despite the unpleasant associations conjured up by the word "bugs," the common name of this group, the Hemiptera, many of its members are very attractive in appearance and quite unobjectionable in their habits. The mouth parts are highly characteristic, forming a long-pointed "beak" used for piercing and sucking. The first jaws are sharp stylets, grooved on their inner sides for conducting fluid to the mouth, and the second jaws are also pointed rods. The third jaws form a kind of sheath, which encloses the others.

Plant bugs feed upon vegetable juices. The largest of them are the cicadas of warm climates, noted for the loud chirping of the males. Aphids or green-fly are familiar objects in gardens, where they play havoc among plants. They are small and have a complicated life history, including winged and wingless forms. During the summer numerous generations are produced independently of sexual processes by *parthenogenesis*, or virgin birth, and these young are born alive. Fertilized eggs are laid on the approach of autumn in tremendous numbers. It has been estimated that if all the individuals of the tenth generation produced from a single aphid egg survived, the collective weight would equal that of 500 million men. Some Hemiptera are aquatic; these include the pond skaters, water boatmen, and water scorpions, living in ponds and rivers.

The curious scale insects include some British pests, and are so called because the female is sheltered under a scale-like shield. The exudations from the bodies of some species are of economic value. Scale insect products are shellac, white wax, and cochineal. The "manna" of the Old Testament was probably of similar origin. The bed-bug, *Cimex*, is a hemipteran. The lice infesting mammals and birds belong to a different order, the Anoplura.

The Thysanoptera are small insects with sucking mouth parts and four narrow, fringed wings, inconspicuous, but sometimes pests. The feet are swollen into bladders at their tips. Such insects may be seen creeping about in flowers. One species injures corn crops and is called the corn thrips.

Insects with Aquatic Larvae

Insects of certain orders, though the adults are terrestrial, pass their youth in water. These include the mayflies (Ephemeroptera), dragon-flies

(Odonata), caddis-flies (Trichoptera), and the alder-flies, among Neuroptera; also certain true flies, or Diptera.

The Ephemeroptera are so-called because the adult life may last only a few hours, though as a larva the insect may have lived as long as three years; the short-lived adults do not feed, they only mate, breed, and die. Mayflies may emerge from the water in swarms; the artificial bait of fly-fishermen often mimics *Ephemera.*

Dragon-fly larvae are fierce carnivores, the older larvae of some species attacking even tadpoles and small fish. The adults are remarkable for their brilliant colours and large eyes; they feed on other insects, taken in flight. Common British forms are *Aeschna* and the fragile damsel-fly, *Agrion.*

The larvae of caddis-flies live in tubes which they construct from pieces of vegetation or shell, or grains of sand. The adults are inconspicuous insects, looking something like moths, and found near water. The alder-fly (*Sialis*) is a blackish insect also found near water, and though its larvae are aquatic, those of the related scorpion-flies and lace-wings are not. The latter, such as *Chrysopa,* have delicate green wings and bright metallic eyes, and are useful in that adults and larvae prey on green-fly and caterpillars.

The aquatic larvae mentioned breathe oxygen dissolved in the water, by means of gills, thin-walled projections of the body (in some cases, within the gut). Adult insects which are aquatic, however, breathe air, and may carry a store of air under the water, trapped under the wings or in hairs covering the body.

LESSON 13

More About Insect Life

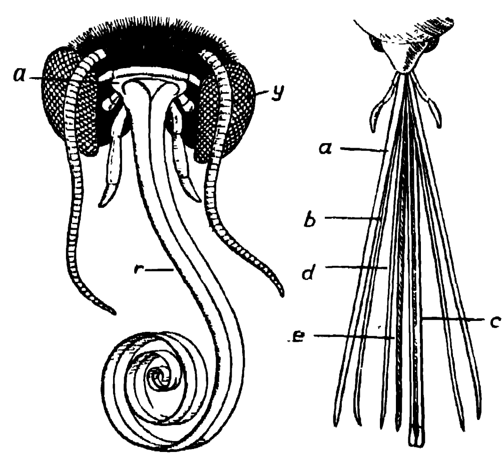
An enormous host of insects—some 250,000 species belong to the order Coleoptera or beetles Such insects have a particularly thick horny investment, and strong biting jaws. The fore-wings are modified into hard wing-covers; the hind wings are membranous—as in straight-winged insects like the grasshopper. While the hind wings of Orthoptera fold up along a set of longitudinal pleats, those of Coleoptera are relatively long and require a transverse fold as well. Some species of beetles have reduced wings. In the life history of beetles there is a well-marked metamorphosis. From the egg hatches out a grub, which, after a time, passes into a motionless pupal stage, and the pupa is ultimately transformed into the perfect insect. Some beetles are smaller than the largest Protozoa, others are larger than the smallest mammals; this is an extraordinary range of size within a single order.

Beetles

The beetles known as "chafers" include dung beetles, cockchafers, hercules beetles, and rose chafers. Perhaps the most interesting dung beetles are the scarabs, of which one species was sacred in Egypt. Their fore-legs are broadened into powerful digging organs, with which subterranean chambers are excavated to serve as larders for the storage of dung, and as nurseries, the eggs being laid in masses of the same material. Hercules beetles are among the largest of insects, and are further remarkable on account of the curious horn-like projections on the body of the male. Rose chafers are beetles of a metallic green colour.

Water beetles are carnivorous types which have become adapted to life in fresh water, though the adults have not lost the power of flight. In Britain's great water beetle, *Dytiscus marginalis,* the large hind legs are fringed with bristles and serve as oars, while the wing-covers form a storeplace for reserves of air The unattractive larvae pierce and suck their prey by means of the large first jaws (mandibles). Whirligig beetles also are aquatic; their spinning movements are due to the action of the second and third pair of legs, which are broadened into beautifully constructed paddles.

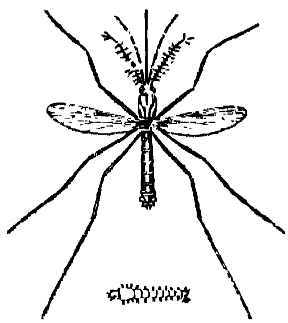
Ladybirds lay their eggs on various plants, and the larvae which hatch out devour green-fly, scale insects, and other pests with avidity, thus



MOUTH PARTS OF INSECTS. Left, of Lepidoptera; a, labrum; y, eye; r, sucking tube. Right, of Diptera (Culex); a, labrum; b, first pair of maxillae; c, proboscis; d, mandible; e, hypopharynx.

From Parker & Haswell, "Textbook of Zoology" Macmillan

entitling them to the affection of the horticulturists. Of an entirely different habit are the beetles of an allied family—germs *Dermestes* -- the larvae of which devour articles of food and clothing, as immature fur beetles, bacon beetles, and horsehair beetles. Nearly related also are the larger death-watch beetles, which make some of the tickings commonly heard in old houses, and which ravage woodwork.



CULEX (mosquito) and larva.
Parker & Haswell

Fireflies and glow-worms have long attracted attention on account of the light they emit. In the Italian firefly the males are by far the more brilliant, and fly about of an evening in large swarms, scintillating like so many tiny lamps. The source of light in Britain's native glow-worm is the wingless female, which doubtless attracts a mate thereby. Probably the same is true of the railway beetle of South America, which is so called because it has a red light at each end of its body and a series of smaller green ones along each side. Blister beetles are so named because a highly irritant substance can be extracted from their bodies – as in the typical case of the Spanish fly, the source of cantharadin. Many beetles, especially weevils, are troublesome pests, eating crops or stored food.

Butterflies and Moths

For beauty and variety of coloration, the Lepidoptera order of insects is quite unrivalled; these are the butterflies and moths. The mouth parts are specialised to form a suctorial organ, which is made up of the second jaws (first maxillae); the first and third jaws are greatly reduced. Each second jaw becomes a half-tube, and the halves are hooked together to form a proboscis, sometimes of great length. With these mouth parts the insects can probe flowers, to feed on nectar.

The life history exhibits a typical and familiar metamorphosis. From the egg, which is often beautifully sculptured, a larva, called a caterpillar, hatches out, and this possesses not only the three pairs of jointed legs characteristic of the order but also a varying number of unjointed *pro-legs* terminating in suckers. After feeding voraciously for a time by means of its powerful biting first jaws, and undergoing a number of moults, which enable it to grow, the caterpillar passes into the motionless pupal stage. The pupa, called a *chrysalis*, may be invested in a protective cocoon. Silk is taken from the cocoon of the moth *Bombyx mori*. The skin of the chrysalis ultimately splits to allow of the escape of the perfect insect or *imago*.

Butterflies are typically distinguished from moths by the club-shaped thickenings at the ends of the feelers or antennae, and by the fact that when settling the butterfly's wings are folded together over the back. In moths the antennae may be of various forms, but are very rarely club-shaped, and the resting position of the wings is horizontal or sloping downwards.

Characteristics of Flies

The enormous assemblage of insects of the order Diptera, most of which are minute, include many species that have earned an undesirable reputation as blood-suckers and pests. Except in fleas and a few others, there are two membranous front wings, the hinder wings having become reduced into vestiges called balancers, which appear to be sensory organs. The mouth parts of the females are often piercing and sucking organs of great efficiency, the first and second jaws being slender lancets protected above and below by upper and under lips respectively. But in other types, like the house-fly, the jaws are modified into a proboscis used for sucking juices and devoid of powers of perforation. Here, a droplet of digestive fluid is ejected on to the fragment of food, and partially digested food materials are then sucked up by the proboscis.

The life history exhibits a marked metamorphosis, which can be illustrated by reference to the blow-flies (*Calliphora*) or the house-fly. The elongated whitish eggs are laid in animal substances, such as meat, and hatch out into limbless maggots of extreme voracity. After growing to a certain size, the maggots become quiescent pupae, enclosed in firm investments, from which the adult flies eventually emerge.

Mosquitoes and gnats are particularly notable for the blood-sucking propensities of the females. The larvae are small worm-like creatures, which may be seen wriggling about in stagnant water; they possess a breathing tube at the tip of the tail, which can be pushed above the water surface to procure air. The

RED ANT. Three individuals of Formica rufa: left, male: centre, imperfect female or worker: right, perfect female. Each form is specially adapted for the part it plays in the anthill community.
From Parker & Haswell

pupa floats at the surface with two breathing tubes projecting from its head. If alarmed, it is able to dive. After a time the pupal skin opens and the perfect insect makes its way out. Midges are minute gnats, the aquatic larvae of which are known as blood-worms. Crane-flies are familiar to most people in the daddy-long-legs (*Tipula*), well adapted for climbing among grasses. The larvae—called leather-jackets—gnaw the roots of grasses and other plants and become pupae in the ground. Sand flies are small gnats of bloodthirsty disposition which have aquatic larvae.

Fleas are wingless Diptera (sometimes considered as a distinct order, the Aphaniptera), which are parasites; there are many species infesting different mammals and birds.

Ants, Bees, Wasps

The order Hymenoptera includes, among many other types, ants, bees, and wasps. They are readily recognized by the presence of four transparent wings traversed by a small number of veins, the hinder ones being much smaller than the foremost ones, to which they are in some instances attached during flight by means of a row of minute hooks. The hinder end of the female's body is commonly provided with a piercing apparatus, which may serve either for boring small holes in which eggs are laid—in which case it is called an *ovipositor*—or as a poisoned sting, useful for offence and defence.

The larvae may resemble caterpillars, or may be pale, helpless, limbless maggots, for the welfare of which more or less elaborate provisions are made by the mother insect. In the case of certain bees and wasps, and the ants, care of the young has been so extended that an elaborate society has developed: only a few females (the queens) are fertile, laying enormous numbers of eggs. The young are cared for by sterile females, the workers. The number of males is much less.

Wood-wasps resemble true wasps imperfectly, for they do not possess the characteristic waist and sting. The giant wood-wasp is a typical species, in which the female has a powerful boring apparatus with two long blades that serve as augers for perforating the trunks of sickly or felled pine trees.

Gall-wasps are minute insects, the females of which lay eggs in soft vegetable tissues, setting up an irritation which results in the formation of an abnormal swelling, known as a gall, within which the larva lives and feeds and grows. The oak tree is victimised by a number of species. The most familiar example is afforded by the small spherical bodies known as oak-apples; other common oak galls look like currants, or circular brown scales (oak-spangles) on the backs of the leaves. Some plant galls are caused by flies, not wasps.

Ichneumon flies lay their eggs in the larvae of other insects, such as caterpillars, which provide the food for the young ichneumon developing within them.

LESSON 14

Scorpions, Spiders, Mites, and Ticks

A well demarcated sub-phylum of the Arthropoda is the Arachnida. This includes terrestrial animals like scorpions, spiders, mites, and ticks, false scorpions, and harvesters—as well as the strange marine creature, *Limulus*, the king crab, and the now extinct sea scorpions.

Terrestrial arachnids are sometimes confounded with insects, from which they differ in several obvious structural details. Arachnids never have feelers or antennae. The head and thorax are invariably fused together to form a unified head-thorax or *prosoma*, consisting of six adult segments bearing characteristic appendages. The first segment, which lies in front of the mouth, has a pair of delicate three-jointed pincers (*chelicerae*); the second segment has a pair of limbs, which may be powerful pincers or slender sensory appendages (*pedipalps*); the remaining four segments bear each a pair of walking legs. The extra pair of walking limbs serves to render arachnids clearly distinct from insects, and the wingless body is a further difference. Moreover, the young arachnid, unlike most young insects, generally closely resembles the adult at hatching.

The hinder part of the adult body consists of 13 segments (though it may be apparently, as in spiders, unsegmented), which form the abdomen or *opisthosoma*.

Scorpions

These arachnids (class Scorpionidea) occur commonly in the hotter parts of the globe; some smaller species live in southern Europe. They lurk under stones and in other dark places, their dull, dark bodies blending well with their drab surroundings. They are generally nocturnal in their habits, and feed upon insects or spiders, and other small creatures, which are seized by the first two pairs of appendages. Grasped in these claws, the prey is helpless. The scorpion then raises its narrow tail over its back and stings the prey. A secretion of a poison gland is injected into the wound made by the sting and has a fatal effect. The prey is

not masticated and swallowed, for the scorpion's mouth is exceedingly small ; but its juices are extracted by the action of a stomach which works like a suction-pump, and which draws fluid into the food canal as water is drawn into a syringe.

The structure and arrangement of the blood vascular system, digestive system, and nervous system, are typically arthropodan, but the respiratory system shows differences from that of the insect. A scorpion does not breathe, like an insect, by means of air-tubes, but by means of four pairs of " lung-books," the slits opening into which are easily seen on the under side of the mesosoma. These organs are chambers, kept filled with air, within which numerous delicate plates, resembling the leaves of a book, are contained. Within the leaves blood circulates, separated from the chamber of the organ by a thin sheet of delicate tissue, through which respiratory exchanges are made.

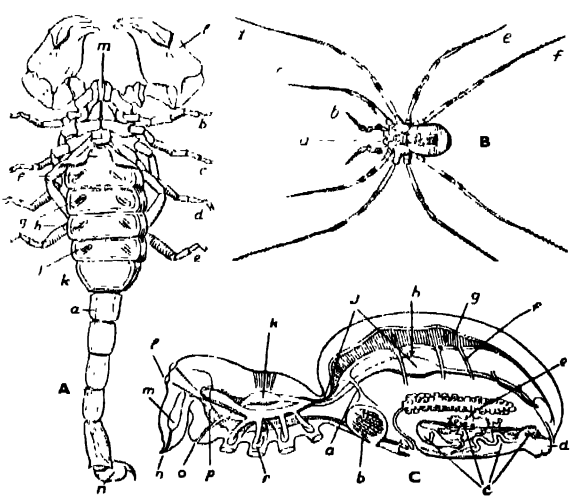
The oldest fossil scorpion known dates from the Silurian and is a marine form. In rocks of similar age are found the sea-scorpions, the Eurypterida, which had some resemblance to scorpions but might grow to a length of six feet. *Limulus*, the king crab, is a surviving marine form, in a separate class, which is a burrowing, sand-living animal, found on the western shores of the North Atlantic and Pacific. It is the last survivor of a waning group, and shows many structural features of an arachnid nature. The front part of the body is covered by a strong semicircular shield or carapace, on the upper side of which the eyes are situated. This region bears six pairs of limbs corresponding to the chelicerae, pedipalps, and walking legs of a spider or scorpion. The bases of the limbs surround an elongated mouth, and they are roughened to serve as grinding jaws (*gnatho-bases*).

The abdominal segments are also fused together, protected by a shield above, and bear a tail-spine, which serves to right the animal if accidentally turned on its back. The hinder appendages of this region, of which there are five pairs, are thin flattened plates to which the gills are attached. The structure of these gills resembles that of the lung-books of scorpions and some spiders, except that they are borne outside the body instead of in enclosed chambers ; it is presumed that the lung-books of terrestrial forms were derived from the gills of aquatic ancestors.

The familiar arachnids of the class Arachnida differ from scorpions in several respects. The abdomen, instead of being elongated and clearly divided into rings, is of rounded form and shows no trace of segmentation. The jaws do not terminate in pincers. The chelicerae have a claw-like end joint, which can be bent down like the blade of a pocket-knife, for grasping purposes. The pedipalps are used as feelers. But, as in scorpions, there are several simple eyes upon the upper part of the prosoma, though the arrangement of these differs in the two classes.

Spiders are every bit as rapacious as scorpions, and likewise suck the juices of their victims. But the prey of the spider is killed or paralysed by the secretion of poison glands that open on the chelicerae. The colours and marking, as in scorpions, render the animal inconspicuous ; some very brightly coloured spiders live on flowers of similar colour. Some spiders possess lung-books, but the more active forms also develop air tubes, or tracheae, which in some species are the only respiratory organs.

The most familiar spiders construct webs of various kinds to serve as snares for their insect prey. Some spiders use silk for cocoon spinning—a device which protects the eggs—others to form retreats, to bind up their prey, to anchor themselves, or to form a " gossamer " drifting line. In the common garden spider, *Epeira*, the silk glands open on six small teat-like projections, the spinnerets, situated on the under side of the abdomen near its hinder end. The ends of these are studded with over 600 minute tubes, some larger than the rest. The fluid which exudes from



ARACHNIDS. A, scorpion : a, first segment of metasoma : b, c, d, e, walking legs of the prosoma : f, g, h, j, stigmata of right side : k, last segment of mesosoma : l, pedipalp : m, chelicera : n, tail. B, a phalangid, misnamed harvest " spider " : a, chelicera : b, pedipalp : c, d, e, f, walking legs. C, diagram of a spider : a, vessel bringing blood from lung-book to heart : b, lung-book : c, silk glands : d, anus : e, ovary : f, artery : g, heart : h, ducts of digestive gland : j, mid gut : k, sucking stomach : l, eye : m, poison gland : n, chelicera : o, mouth : p, brain : r, lobes of stomach.

From Borradaile, Potts, Eastham & Saunders, " The Invertebrata," Cambridge University Press

each tube at once hardens into a thread ; each line of the web is complex, consisting of strands woven together and coated, in some instances, with adhesive material.

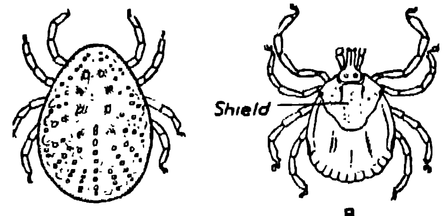
The sheet webs and tubes seen in country lanes are made by a near relative of the house spider. Other spiders make hammocks and labyrinths ; in the common garden spider — which makes wheel-like snares —the art of spinning is brought to perfection. The web is vertically disposed in a hedge or in some other convenient place—often near water, where flies and gnats abound —and is made by the female. To begin with, a roughly quadrangular frame is constructed of foundation lines, and firmly fixed to supports. Then radial strands, arranged like the spokes of a wheel, are laid down. Later, the radial threads are united by a spiral thread, which commences near the middle of the hub and runs outwards. This first spiral is gradually removed and replaced by a second spiral, coated with adhesive material, which runs towards the centre of the hub, without reaching this point—where the non-viscid first spiral is allowed to remain. The spider takes up occupation either on the hub of the snare or in a near-by retreat connected with the hub by special threads. The spider does not become trapped in its own web, because its legs are covered with an oily secretion which prevents adhesion.

The floating lines of silk which drift through the air in spring and early autumn are spun by young spiders of various species to serve as means of dispersal. The young spider stands on a firm object, facing the wind, and spins mooring strands. The end of the abdomen is then turned up and a thread is woven which streams out into the wind. When the thread is sufficiently long to support the weight of the spider, the moorings are cut and the spider drifts away, ultimately to land far from its starting-point.

Variations on a Web

The water spider constructs a web under water for the protection of its eggs. The web is really a thimble-shaped nest, moored to water plants and smeared externally with liquid silk to make it air-tight. The nest is filled with air, brought down from the surface of the pond in successive bubbles adhering to the hairy body of the spider.

Some spiders do not construct webs but use their silk merely for lining their dwellings, which are commonly underground. The tarantula spider stalks its prey and seizes its victims by a sudden spring when sufficiently close. The trap-door spiders are hunters, noted for the neat way in which their underground retreats are constructed. A cylindrical burrow is excavated and lined with silk, intrusion being prevented by the circular trap-door made of particles of earth cemented together with silk and provided



TWO FORMS OF TICK. A, Argas ; B, Amblyomma. The former is distinguished by its leathery skin, B by the hard shield which covers the whole body of the male, and the front part of that of the female, as shown here.

From Borradaile, etc., "Invertebrata," Cambridge University Press

with a durable silken hinge. Bird spiders are of large size and can dispatch frogs and small birds, in addition to insects and other spiders.

Many arachnids which do not belong to the Arachnida are often wrongly called spiders. The long-legged harvest spider or harvest-man is not a spider at all, for the abdomen is segmented and is united with the prosoma by its entire width—that is to say, there is no " waist." There are no spinning glands and the chelicerae are pincer-like. This arachnid belongs to the class Phalangida. Another form which is commonly miscalled a spider is the minute red-spider, which causes so much damage to various plants. This belongs to the Acarina, the class of mites and ticks.

Mites and Ticks

These are mostly of very small size, and all three regions of the body are fused together into an ovoid mass. The mouth parts are typically suctorial. In many free-living forms the chelicerae are piercing claws, while the pedipalps are leg-like. But in the familiar cheese-mite, *Tyroglyphus*, the chelicerae are pincer-like and the pedipalps are no longer leg-like. An adult tick may attain the size of a hazel-nut ; the mites are generally very much smaller. Two kinds of ticks are recognized, called " hard " and " soft " ticks respectively. The former have a hardening of the upper surface which takes the form of a shield. The soft ticks have soft flabby bodies. Both hard and soft kinds are parasitic on a wide variety of vertebrated animals.

Soft ticks remain on the body of the host only until gorged with its blood, and usually spend the light part of each day sheltered in crevices near the habitat of the host. *Argas* is a genus of bird ticks with species parasitic on fowls, ducks, geese, turkeys, and pigeons the world over. Hard ticks develop through a series of interesting stages. The eggs are laid on herbage and hatch out in two to six months into larvae with only three pairs of legs. The larva seeks

a host, on which it becomes gorged with blood, later to fall to the ground. Moulting takes place on the ground, the moulted tick possessing the full number of legs but imperfectly formed sexual organs. It is called a "nymph." This seeks a host, gorges itself with blood, and falls to the ground in order to moult and to become mature. Mating takes place on the ground, and the fertilized female must again seek a host and feed, and must once more come to the ground in order to lay the eggs. In view of the slender chance any individual larva has of completing its life history, it is scarcely surprising that the number of eggs laid is very large. Of the 5,000 to 20,000 eggs produced, very few will reach the adult stage, despite the astonishing resistance shown by ticks to starvation.

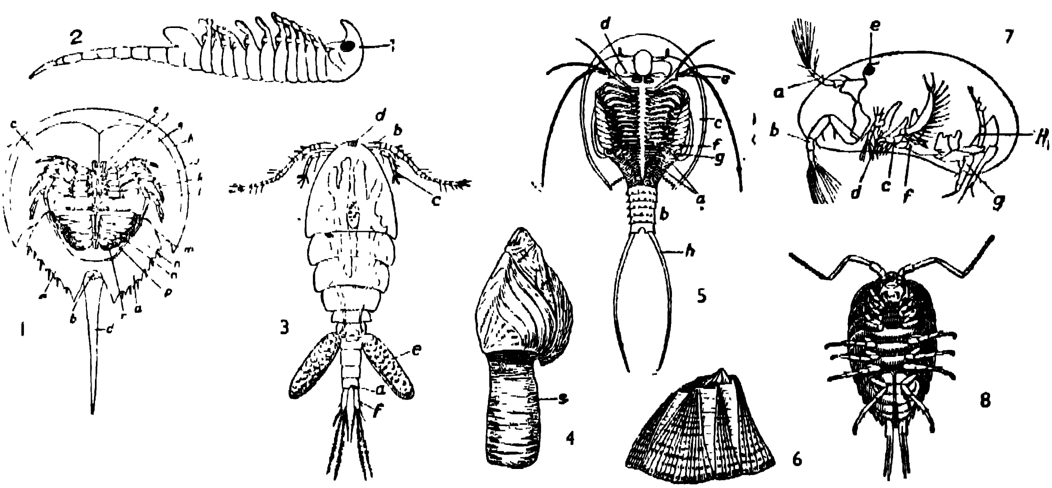
LESSON 15

Crabs and other Crustaceans

CRABS and lobsters, prawns and shrimps, are of gastronomic interest ; minute and less familiar crustaceans like copepods—which form immense swarms in the surface layers of the sea—form an important element in the food of fishes and hence, indirectly, in our own.

The exoskeleton of the larger crustaceans is highly charged with limy materials. The body is divided into segments, those of the head being fused together ; in many forms those of both head and thorax are likewise fused into a *cephalothorax*. Head, thorax, and abdomen bear limbs, a pair on each segment. A difference from the insects and myriapods is the presence of two pairs of antennae borne on the head, the appendages of the second and third segments. Being aquatic, the Crustacea breathe through thin walled gills borne on certain limbs. With the exception of certain parasitic forms, all Crustacea feed by means of the limbs on the head and body, which are variously modified according to the type of food. The Crustacea are typical arthropods in the form of the blood system and nervous system. There are five main classes of Crustacea. The group is an ancient one, and certain of the classes were already distinct when the fossil evidence begins.

The name of this group is derived from the nature of the limbs, which bear gills but are also used for swimming and for capturing food. Most branchiopods are small, and the exoskeleton is therefore thin and flexible, not impregnated with lime as is that of large forms like crabs. One of the largest members of the class, *Apus*, is about an inch long. It possesses a large head-shield, or *carapace*, which covers the chief part of the body. The animal rows itself



CRUSTACEA. 1. Limulus (king crab), under side : a, abdomen ; b, anus ; c, carapace ; d, caudal spine ; e, chelicerae ; f, mouth ; g, pedipalps ; h, j, k, l, prosomatic appendages ; m, n, o, p, r, gill-books. 2. Chirocephalus swimming on its back. 3. View of Cyclops from above : a, position of anus ; b, antennule ; c, antenna ; d, eye ; e, egg-sacs ; f, ramus of caudal fork. 4 and 6. Barnacles : s, stalk. 5. Lower side of Apus : a, abdominal limbs ; b, limbless somites of the abdomen ; c, carapace ; d, mandible ; e, first thoracic limb ; f, tenth thoracic limb ; g, egg pouch on eleventh thoracic limb ; h, ramus of caudal fork. 7. Side view of Cypris : a, antennules ; b, antennae ; c, first maxillae ; d, mandibles ; e, eye ; f, second maxillae ; g, h, thoracic limbs. 8. Lower side of Ligia, the slater.

From Borradaile, Eastham, Potts and Saunders, "The Invertebrata," Cambridge University Press

along by means of the numerous leaf-like appendages, as does *Chirocephalus*, the fairy shrimp, which is about half an inch long, translucent and colourless, without a carapace. The movements of the limbs serve to sweep food particles along a median gully between the bases of the limbs and into the mouth. Swimming movements are thus combined with feeding ones. These forms are inhabitants of temporary fresh waters such as seasonal ponds. In the common water flea, *Daphnia*, the carapace takes the form of a bivalved shell which encloses the trunk but not the head.

Daphnia, and its near relations, live in fresh water, being plentiful in lakes and streams or ditches ; like the aphids among insects, the water fleas have a life history which includes a series of generations produced asexually, by parthenogenesis ; this happens during the summer, but as autumn approaches males as well as females are born, and mate to produce, sexually, *winter eggs*, which have thick shells and do not hatch until the spring, when another generation of females emerges, to reproduce asexually. Some branchiopods are marine.

Ostracoda

These are small crustaceans, widely distributed in fresh and salt water, but difficult to distinguish one from another because the carapace forms a bivalve shell enclosing the head and body. An example is *Cypris*. The body is much shortened, and the largest limbs are the two pairs of antennae on the head. Feeding methods vary widely. Fossil ostracods are known since the Cambrian.

Copepoda

The members of this class have six thoracic segments, one or two of which are fused with the head, and an abdomen of four segments without limbs. They are small, usually a few millimetres in length, but they form very important food organisms in the sea, constituting valuable links in food-chains—series of animals the higher members of which feed upon the lower. They feed upon minute plants (*diatoms*) and in turn are preyed upon by other crustaceans and fishes. One species forms the food of herrings, another species constitutes the bulk of the food of the " whalebone " whales. So abundant are these animals that the sea is often coloured bright red by their tremendous swarms. There are fresh-water forms as well as marine ones ; a common pond dweller is *Cyclops*, a small, pear-shaped white animal, the female of which is easily recognizable by the characteristic paired egg-sacs hanging from the thorax. This genus owes its name to the single median eye, which is, however, also found in other free-living copepods. Some forms have become parasitic, usually clinging to the skin or gills of fishes and sucking their blood. The bodies of these parasites often become shapeless lumps, and they are only recognizable as copepods by the presence of characteristic paired egg-sacs and by the developmental stages of the young, which resemble those of other copepods. In some species the males are minute and are found clinging to the larger females. These are parasites of marine fishes.

Argulus, the fish-louse often found on freshwater fishes in Britain, is not a copepod but is a related form. It attaches itself to a fish by suckers which are modified limbs, but can swim strongly between meals.

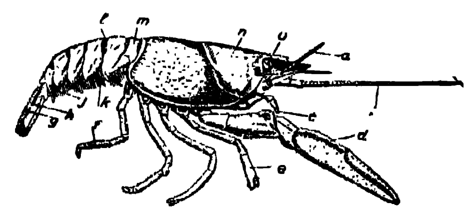
Cirripedia

This class contains the familiar animals known as barnacles, which lead sedentary lives under the shelter of a large shield which is a part of the body. They have forked, bristly limbs, which are used exclusively for procuring food, forming a sweep-net. The tail is reduced and the body is fixed by the head end, well seen in the ship barnacle (*Lepas*) and the acorn barnacle (*Balanus*), which abounds on rocks between tide marks. In both instances the body is protected by shelly plates, but the head end of the ship barnacle is drawn out into a long fleshy stalk.

Many near relatives of the barnacle are parasites, one of the most remarkable examples being *Sacculina*, of which the adult female is often found attached to the under side of crabs. *Sacculina* is provided with root-like branching threads, which ramify through the tissues of the unfortunate host and serve to absorb its blood and body fluids. The larva indicates the parasite's true affinity.

Malacostraca

This class includes the lobsters and crabs, also forms which have become adapted to life on land, such as the sandhoppers and woodlice. Lobsters and crabs are " ten-footed " crustaceans (order Decapoda), so called because there are ten obvious limbs—the two great pincers



COMMON CRAYFISH. Side view of Astacus fluviatilis : a, antennule ; b, antenna ; c, third maxilliped ; d, chela ; e, first walking leg ; f, fourth walking leg ; g, telson ; h, last appendage ; j, last segment of abdomen ; k, swimmerets ; l, abdomen ; m, first segment of abdomen ; n, carapace ; o, eye.

From Borradaile, " The Invertebrata "

and four pairs of walking legs. Twenty segments are comprised in the body, of which six, eight, and six belong to head, thorax, and abdomen respectively. Head and thorax are roofed over by a carapace, but this is reduced in some forms. Limbs are borne on all three regions of the body and are typically forked, though in many instances the outer branch of the fork has been lost. The abdominal limbs are forked paddles known as *swimmerets*, best seen in large-tailed Decapoda like lobsters, crayfishes, and prawns. In such animals the powerful downward movement of the tail, propelling the animal tail foremost, forms an escape mechanism. In short-tailed Decapoda like the crab, the swimming habit has been abandoned for a creeping one. Head and thorax are broadened ; the greatly reduced and insignificant abdomen is tucked up on the under side of the thorax.

The second and third head segments bear each a pair of antennae which are sensory organs. The last three of the head segments bear jaws named, from front to back, mandibles and first and second maxillae. An oval plate is attached to the second maxilla and lies in front of the gill cavity, a chamber under the sides of the carapace containing the delicate gills. This plate serves as a bailing organ, its movement ensuring that a continuous current of water with dissolved oxygen shall move over the gill lamellae. The first three segments of the thorax have appendages known as foot-jaws or *maxillipeds*. Jaws and foot-jaws alike help to handle and to break up food. These structures are supplemented by a complex chewing or grinding arrangement contained within the stomach. Lobsters and crabs have stalked eyes. The sandhoppers and woodlice belong to the orders Amphipoda and Isopoda respectively, the latter having the legs all more or less alike, while the former do not. Most members of the groups are aquatic, though these forms have become terrestrial ; not very successfuly so, for they are confined to damp environments. A sea-shore Isopod, the slater, *Ligia*, is illustrated in page 2057.

Though the Crustacea as a whole are a very ancient group, the highly developed decapods date only from the Triassic. More primitive Malacostraca, however, are found in the Palaeozoic together with some early Branchiopoda and Ostracoda

LESSON 16

Snails, Shell-fish, and Other Mollusca

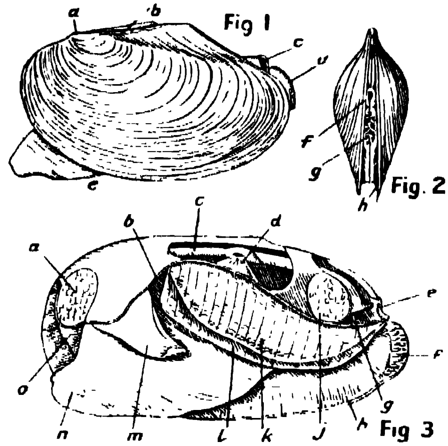
The edible Crustacea are often called " shell-fish," and so are many members of another phylum, the Mollusca, readily distinguished from the Arthropoda because their bodies are not divided into segments provided with limbs, and are commonly protected by a conspicuous calcareous shell. The under side of the body of a mollusc is thickened to form a muscular projection, the " foot," by which locomotion is effected. In most molluscs there is a well-developed head. As in the Arthropoda, the body cavity is an expanded blood system, traces of the coelom remaining only in the reproductive organs and kidneys and in the space enclosing the heart. The aquatic forms breathe by means of gills, which may also be used in feeding. The nervous system consists usually of three pairs of ganglia connected by nerve strands, but not forming a chain as in the Arthropoda. The phylum is divided into five classes, of which the main ones are the Gastropoda, including snails and slugs, whelks, periwinkles and other univalve (one-valved) " shell-fish " ; Lamellibranchiata, including the bivalve (two-valved) mussels, cockles, and oysters ; and Cephalopoda, including cuttlefish, squids, octopus, and pearly nautilus.

Lamellibranchiata

The most obvious character of this class is the possession of an external limy shell made up of two pieces or valves placed on right and left sides of the body. They are connected together on the upper side by an elastic ligament, which causes the shell to open or " gape " when its action is unopposed, as in the empty shell. Along the inner side of the hinge of the shell are often interlocking teeth and sockets, which serve to prevent displacement when the shell is opened or closed. Two fleshy bands (in some forms only one) stretch across from one valve to the other near the front and hind ends of the shell ; these are the *adductor* muscles, by the contraction of which the shell is closed. The eater of oysters slices through these in opening the oyster shell.

The Fresh-water Mussel

If one cuts through the adductors of a bivalve mollusc like *Anodonta*, the fresh-water mussel, it is found that each valve is lined by a soft flap of the body wall, which is the *mantle*, the chief agent of shell formation. As the animal grows, the shell is made correspondingly larger by additions at its rim, which additions are laid down by the mantle edge. Therefore lines of growth—points at which one addition follows another—encircle the *umbo* or beak of the shell, which is the oldest part and which is usually found nearer the front end of the animal. The pearly or nacreous lining of the shell is formed by the entire outer surface of the mantle.



ANODONTA. 1. From left side. 2. From hinder end : a, umbo ; b, ligament ; c and f, exhalant siphon ; d and g, inhalant siphon ; e, foot ; h, mantle. 3. Most of left mantle lobe removed : a, front adductor muscle ; b, cut edge of left mantle lobe ; c, hind part of intestine ; d, heart ; e, exhalant siphon ; f, inhalant siphon ; g, anus ; h, right mantle lobe ; j, hind adductor muscle ; k, left external gill lamina ; l, left internal gill lamina ; m, labial palp ; n, foot ; o, mouth.

From Parker & Haswell, "Zoology," Macmillan

On raising the mantle flap of a mussel, one sees below it the complicated plate-like gills from which the class derives its name—two laminae on each side, one lying on the inner side of the other. Each is really a double structure which hangs bag-like from the lower surface of the body. The gills or *ctenidia* present a very complicated appearance under the microscope, consisting of a lattice-work of fine filaments bearing ciliated cells. The action of the cilia sweeps a steady stream of water through the lattice-work and into the cavity of the lamella from the cavity between the mantle lobes. This stream of water passes into a large chamber lying above the ctenidia and thence to the exterior by a small tube, the *exhalant siphon*, seen at the hinder end of the animal between the valves of the shell. The stream is maintained by the entrance of water through another tube, the *inhalant siphon*, lying immediately below the exhalant siphon. This water carries oxygen in solution and, since the gills are thin and richly vascularised, gaseous exchanges take place here and also in the mantle fold, which is abundantly supplied with blood vessels as well.

The water circulation through the body of the mussel serves another important function. Contained in it are minute organisms which constitute the food of the mussel. These are entangled in sticky mucous threads secreted by some of the cells of the gill-lamellae, and are wafted by the action of special cilia towards the front end of the animal, where the mouth is situated. The ctenidia are specially modified feeding organs. When the train of particles reaches the anterior end of the animal, it is caught up by one or other of the two triangular flaps which lie on either side of the mouth. These flaps or *labial palps* are also ciliated, and serve to pass on the food train to the mouth.

Means of Locomotion

Projecting between the lamellae of the ctenidia of the fresh-water mussel is the large orange-coloured foot shaped like an axe-head and projecting to the front. This is the organ of locomotion. When blood is pumped into it, it is stretched forward, and then by contraction of its muscle fibres a shortening is effected by which the body is dragged along over the surface of the mud of the pond floor. The foot also contains several coils of the intestine, which communicates in front with a capacious stomach embedded in darkly coloured digestive glands, and which opens into the exhalant siphon behind. The reproductive glands are also lodged in the foot.

There are bivalves in which the siphons are greatly elongated. Such a bivalve can remain sheltered in its vertical burrow in sand or mud, and while its siphons reach the surface it is able to feed and respire in comfort. The ends of the siphon are pigmented and sensitive to changes of light intensity. Should a shadow fall upon them they are drawn in, and the animal burrows to avoid the danger which may threaten it. Some bivalves burrow more rapidly than others, the best burrowers having a long narrow shell with the foot projecting in front. *Solen*, the razor-shell, has these characters well marked. Some species are able to bore through wood or stone, the body twisting on its long axis, while the roughened front end of the shell is brought to bear on the structure to be bored through. The piddock (*Pholas*) is an example. The most notorious borer is the so-called ship worm, *Teredo*, which can play havoc with the timbers of ships and piers.

LAND SNAIL. Helix pomatia, the Roman or edible snail.

In the common scallop, *Pecten*, the foot is reduced and the shell is rounded in outline. The animal normally lies on its right side, having two dissimilar valves, but it is by no means altogether sedentary; it can swim with a butterfly-like motion by the flapping action of the valves of its shell when

occasion demands. Many bivalves become temporarily or permanently fixed when adult. The edible mussel, *Mytilus edulis*, moors itself by black threads (*byssi*). Another familiar fixed bivalve is the oyster, which has no foot and which, like *Pecten*, has only one adductor muscle. The animal is fixed by the substance of the thick and deeply concave left valve, lying below, while the right valve serves as a lid, which can be raised for the admission of water currents. Most aquatic molluscs, especially the more sedentary forms, produce larvae which swim freely in the sea and ensure the distribution of the species. Such larval stages are suppressed in some shore living gastropods, and in fresh water forms. *Anodonta* retains its young within its mantle-cavity for a time; when released they attach themselves to fish, as parasites, until they are grown up.

Gastropoda

In a typical gastropod, like the snail, the shell is of spiral form and the body of the animal is withdrawn into it for protection. The under side of the foot is a flat sole-like expansion, exuding slime, and by waves of muscular contraction the animal is able to glide along a smooth surface, as the most casual observer of this garden pest must have observed. The mouth is provided with a peculiar rasping organ, by which particles are scraped from the food object. It consists of a projection rising up from the floor of the mouth, over which is stretched from front to back a horny ribbon, the *radula*, studded with rows of minute teeth.

Some snails live in the sea, and most of these respire by means of a plume-like gill situated in a cavity placed far forward on the upper side of the body and roofed by a membrane, the mantle, which helps to form the shell. As in bivalves, the purified blood flows into a two-chambered heart, which pumps it through the body. Some sea snails are vegetarian, others are carnivorous and predaceous. The periwinkle *Littorina*, and the limpet *Patella*, are herbivores; *Buccinum*, the whelk, is carnivorous. Some carnivorous types prey upon other shell-fish. Some marine gastropods have lost the shell; such forms as *Eolis* eat coelenterates and transfer the stinging cells of the prey, undischarged, to projections on their own backs, where they are used for defence. These naked gastropods may be delicately coloured and many are very small. Others, such as the sea-butterflies, live in the surface waters of the sea and are transparent.

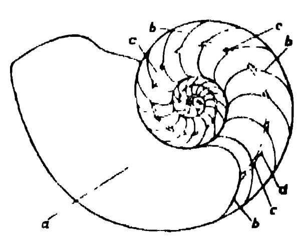
Land snails have probably descended from aquatic ancestors, but have lost their gills and have converted the gill chamber into an organ for breathing air, a sort of lung. Some of the lung-snails have taken to living in fresh water, and when these are kept in aquaria they can be seen to come to the surface from time to time to obtain air. The common pond snail, *Limnaea*, is a familiar form, often seen crawling shell downwards along the surface film where air and water meet.

LESSON 17

Cuttlefish, Squids, and Octopuses

CUTTLEFISH, squids, and octopuses are active and predaceous molluscs, far more highly organized than any members of the other classes previously considered.

In striking contrast to the lamellibranchs or the gastropods, the cephalopods are capable of extreme rapidity of movement. They possess a pair of prominent eyes, set at the sides of the head, which in degree of complexity closely approach those of the fish. The foot is fused with the head, and this region is drawn out into a number of arms—eight in number in the octopus, with the addition of two greatly elongated arms or tentacles in the cuttlefish and the squid. The inner sides of the arms and the swollen ends of the tentacles are studded with numerous suckers, by means of which these creatures cling tenaciously to prey.

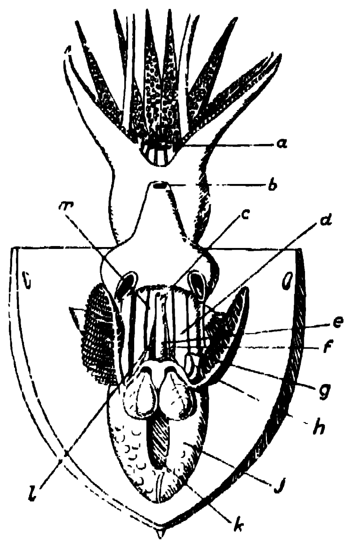


NAUTILUS POMPILIUS. Section of shell showing the septa (b. b), the septal necks (c, c), the siphuncle (d, represented by dotted lines), and the large body chamber (a).
Parker & Haswell

The mouth is within the ring of arms and tentacles surrounded by a fleshy circular lip, which partly hides from view a pair of powerful horny jaws resembling the beak of a parrot. There is also a tongue which carries numerous fine hooked teeth. Below the head is a wide aperture opening into the mantle cavity, which contains the gills, and into which open the excretory and genital apertures, and also the ink-sac, of which more later. When the muscular walls of the mantle relax, water is drawn into the enlarged mantle cavity, to bathe the gills. On contraction of the mantle muscles, water is forced out again, not by the inhalent aperture but through the funnel, a structure protruding below the head; the wide base of the funnel has a peg and socket arrangement attaching it to the mantle wall to ensure

that all the exhalent stream of water leaves by this route. In the living cephalopod the funnel alternately opens and shuts, water being expelled rhythmically from the body, carrying away faeces from the intestine, waste gases from the blood, and the products of the excretory and reproductive glands. The funnel also plays an important part in locomotion, since the animal can propel itself by means of the jet of water ejected from the backwardly turned tip of the funnel. If alarmed, it shoots out a strong jet of water which propels the animal backwards with great rapidity. At the same time an inky fluid is discharged and forms a dark obscuring cloud under cover of which the animal escapes. This fluid is the secretion of a glandular bag, the ink-sac, in which it is stored until required. The pigment sepia was prepared originally from the ink-sacs of cuttlefish of the species *Sepia officinalis*. Cuttlefish and squids can swim also by undulatory movements of fins at the sides of the body. The activities of the animal are controlled by the action of a complex nervous system. As in other molluscs, nerve cells are aggregated into ganglia, which in the cephalopod are large and closely clustered around the first part of the food canal, immediately below the mouth, forming a brain. From the ganglia, nerves are given off to the eyes and arms, as well as to the viscera and to all parts of the body.

Living cephalopods are able to change colour in a remarkable fashion, by means of the expansion or contraction of special pigment-containing cells in the skin, the *chromatophores*, which are under nervous control. Cephalopods can use the colour changes to make themselves match their background, and can produce



CUTTLEFISH. Female, seen from the lower and hinder side, the wall of the mantle-cavity divided along the middle line and the two flaps spread out to expose the contents : a, mouth ; b, external opening of funnel ; c, anal aperture with lateral appendages ; d, neck muscles ; e, rectum ; f, left kidney aperture ; g, oviduct ; h, left ctenidium ; j, ovary ; k, ink-sac ; l, ink-duct ; m, digestive gland.

From Parker & Haswell, "A Text-book of Zoology," Macmillan & Co., Ltd

patterns which are characteristic of certain physiological situations, as when the animal is frightened.

In squids and cuttlefish the shell is represented only by an internal plate which gives rigidity to the body ; in the octopuses it is lost entirely. Fossil cephalopods had better developed shells, and so has the pearly nautilus ; the shell of this form, shown in page 2061, is spiral, and internally divided into chambers. The animal lives in the last chamber, the others being filled with gas, for flotation. The nautilus swims in shallow waters in the South Pacific, often among coral reefs. Its ancestors have been found in Cambrian rocks.

The cephalopods are among the most highly organized invertebrates. Many squids in particular rival the fishes for dominance of oceanic waters. They are fast swimming, and difficult to catch in trawls, so that it is often not realized how common they are. Particularly in the southern oceans they are an important food source for larger carnivores. The sperm whales feed on giant squids living in very deep water, which are rarely seen, though specimens of *Architeuthis* have been recovered which show that this form of squid can reach a length of over 50 feet and is the largest invertebrate known.

Cephalopods are either male or female, and the sperm, and egg-producing organs (testes and ovaries), form a compact mass near the end of the animal farthest removed from the mouth. A remarkable feature of the male is the production of chitinous capsules or spermatophores filled with sperms, which are transferred to the mantle cavity of the female by a specially modified arm.

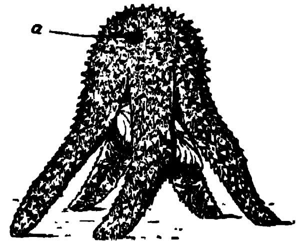
LESSON 18

Echinoderms or Spiny-skinned Animals

ECHINODERMS, which get their name from Greek words meaning spiny-skin, differ from most animals considered thus far in the nature of their symmetry. Instead of having bodies with definite fore and hind ends and right and left sides, each the mirror image of the other (bilateral symmetry), they resemble a star, or the head of a regular flower, a type of symmetry called radial, which also occurs in the phyla Coelenterata (polyps and jellyfish).

The Echinodermata are exclusively marine, but may live at any depth in the sea, from the shore

between tide marks to the bottom of the deep oceans. The animals included in the phylum fall into five clearly defined classes: (1) starfishes (Asteroidea); (2) brittlestars (Ophiuroidea); (3) sea-urchins (Echinoidea); (4) sea-cucumbers (Holothuroidea); and (5) sea-lilies and feather-stars (Crinoidea).



STARFISH in act of devouring a mussel in the manner described in the text; a, madreporite, through which water enters.
Borradaile, etc.

Starfish

These animals, so called because of their star shape, are among the most familiar creatures of the seashore. The commonest kinds—like *Asterias rubens*, the common red starfish found on beaches—have five arms radiating from a central disk. The mouth lies in the centre of the disk on its under side. It leads into a capacious stomach, the first part of which can be protruded from the disk and wrapped around the prey. Starfishes prey upon bivalve molluscs to such an extent as to menace the shellfish industry. The starfish arches its body over that of the mussel or oyster, and attaches its tube feet to the valves. The shell is gradually forced open by the long sustained pull of the tube feet (for the powerful adductor muscles of the bivalve, though much stronger than the tube feet, tire more quickly) and the succulent body of the mollusc is drawn into the protruded stomach of the starfish.

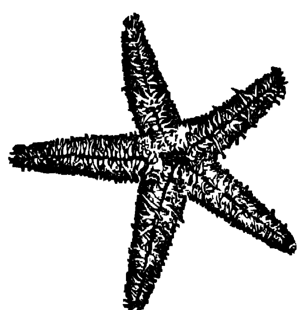
One of the most interesting features of the starfish is the way in which it moves about. It crawls along or climbs by means of numerous sucker-like organs lodged in grooves, called *ambulacral grooves*, that run along the lower sides of the arms. These tube feet are generally distended with sea water, their cavities being continuous with certain definite channels and canals, which pass along the arms and around the disk. These canals constitute the water vascular system, characteristic of echinoderms.

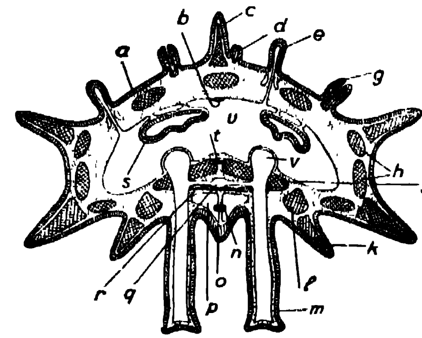
On the upper side of the central disk and towards the interval between two of the arms lies a small furrowed plate, the *madreporite*, which is perforated with numerous fine pores, seen only with the help of a hand lens. The perforations lead into fine canals lined with cilia, which are continuous with the canals of the water vascular system and so with the cavities of the tube feet.

Organs of the Starfish

The base of each tube foot is swollen into a vesicle or *ampulla* with muscular walls which is a reservoir for fluid used in connexion with the activities of the tube feet. By contraction of the ampulla water is forced into the tube foot, which is thus extended. The action of the cilia in the madreporite canals keeps the system turgid and so allows the tube feet to function. Being thin walled, the tube feet supply a respiratory surface, but thin walled papillae on the back of the starfish also have this function.

At each side of the ambulacral grooves of the starfish's body are two or three rows of calcareous spines, movably articulated with plates in the body wall by means of ball-and-socket joints. Nearer the upper surface are three rows of stout immovable spines, while on the upper surface are numerous shorter immovable spines arranged in irregular rows along the arms. Some of the spines, especially those of the lower surface, have microscopic pincers borne on short flexible stalks. These are the pedicellariae: they serve to keep the surface of the animal clear of sand grains and minute sessile organisms, which are picked off the soft membrane that covers spines and plates as quickly as they fall on it. At the extremity of each ambulacral groove is a small bright red eye-spot, overhanging which is a minute tentacle, similar to a tube





STARFISH. Above left, oral or under surface showing the tube feet. Lower, transverse section of arm: a, epidermis; b, muscle which straightens arm; c, spine; d, one of small pedicellariae with crossed jaw ossicles; e, gill; g, one of large pedicellariae whose jaw ossicles are not crossed; h, ossicles; j, ambulacral ossicle; k, adambulacral spine; l, adambulacral ossicle; m, tube foot; n, radial blood vessels; o, radial nerve; p, radial perihaemal vessel; q, radial water vessel; r, muscle which narrows ambulacral groove; s, pyloric caecum; t, muscle which opens ambulacral groove; u, perivisceral cavity; v, ampulla.

From Parker & Haswell, "Textbook of Zoology," Macmillan; and Borradaile, Eastham, Potts & Saunders "The Invertebrata," Cambridge University Press

foot, but without a sucker. These are the organs of sight and smell, the latter being more strongly developed than the former in starfishes.

Internal System

The internal organs of the starfish project into a capacious cavity in the disk and arms, which is the coelom. The mouth leads into a stomach which occupies most of the space within the disk, and is divided into two parts. From the part farthest removed from the mouth, eight long digestive sacs are given off, two of which pass into each arm. The walls of these caeca secrete digestive fluid and are to be regarded as digestive glands. The last part of the alimentary canal is a short intestine, which opens to the exterior by a small anus, almost in the centre of the upper surface of the disk.

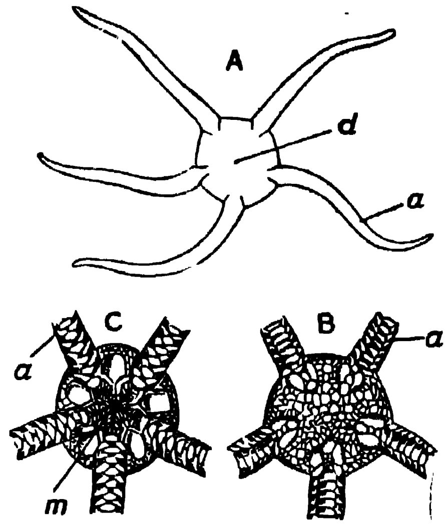
The nervous system is not highly developed. A net of nerve cells underlies the epidermis of the whole surface. In each ambulacral groove between the rows of tube feet is a strip of nervous tissue, the radial nerve. This links up with a pentagonal strip of similar tissue, the nerve ring, surrounding the mouth. The blood vascular system shows a similar arrangement. The gonads are built upon the same wheel-like plan, the ovaries or testes resembling small bunches of grapes in the cavity of the disk between adjacent arms. Eggs and sperms are passed to the exterior through minute openings on the upper surface.

A starfish hatches from the egg as a bilateral *bipinnaria* larva, the delicate body of which is drawn out into arms covered with cilia. The majority of echinoderms have free-swimming larvae which float in the sea, and the bipinnaria is characteristic.

Brittlestars

These animals are the most active of all echinoderms, and obtain their name from the habit they have acquired of breaking into pieces when touched or otherwise irritated. The class name, Ophiuroidea, refers to their wriggling serpent-like movements. The arms of the ordinary starfish are merely continuations of the central disk into which glandular prolongations of the stomach extend. Brittlestars also possess radiating arms, but these are narrow and serpentine, sharply marked off from the disk and without digestive pouches.

In brittlestars the ambulacral grooves have been converted into closed canals lying buried in the body wall protected by calcareous plates. At the sides of the plates project slender tube feet, which, being devoid of suckers, are of little



BRITTLESTAR. A, outline of Ophioglypha lacertosa. B, central disk, aboral surface. C, the disk, oral surface, showing mouth : a, arm ; d, disk ; m, mouth.

Parker & Haswell

use in climbing. The brittlestar uses its mobile arms for moving about, but independently of the action of the tube feet. One arm is extended in front, while the others row the animals along over any surface by series of spasmodic movements. Spines on the arms help to get a purchase on stones and other objects. It sometimes captures its prey by coiling an arm around it and forcing it into the mouth. The thin, soft epidermis of the starfish is vestigial in the brittlestar, and in its place is a strong circle which defies laceration.

Other features serve to render the Ophiuroidea distinct from the Asteroidea. The alimentary canal is a mere bag, which cannot be protruded through the mouth, and this opening is armed with sharp spines that serve as teeth. *Ophiothrix fragilis*, the commonest brittlestar, feeds on microscopic sea plants and on decaying matter occurring in the mud on which it lives ; it shovels sand and mud into its mouth with the first tube feet on each arm. These tube feet are continually active, throwing food into the mouth and sweeping away undigested materials from it. The egg of the ophiuroid develops into a larva totally dissimilar from the parent and different from the bipinnaria of the starfish. It has long slender arms supported by fine calcareous rods and clothed with fine cilia, and bears a closer resemblance to the larva of the sea-urchin.

LESSON 19

Sea-urchins, Sea-cucumbers, and Sea-lilies

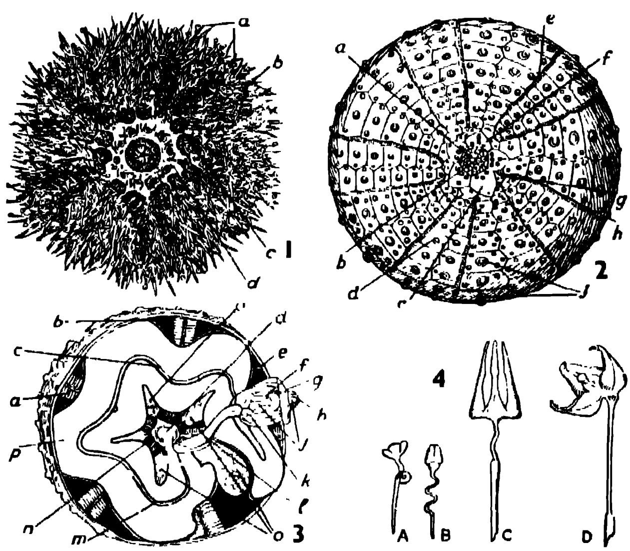
An ordinary or regular sea-urchin is of spherical form and covered with spines. Hidden in the spines, near the lower pole of the body, is a small mouth surrounded by soft skin, and at the upper pole is the anus. The spines are attached by ball and socket joints and muscles to calcareous plates in the skin, arranged very regularly in 20 rows or meridians, and disposed in 10 double sets. Five of these sets are perforated by minute pores, through which the tube feet project. The sucker-like action of the tube feet is greatly enhanced in sea-urchins, which can cling to a surface so strongly that if one attempts to pull the animal away, the tube feet may break rather than release their hold. The spines also assist in holding the animal in rock crevices, which is necessary for a shore-living animal living on a coast subject to wave action. In some tropical species of sea-urchin the spines serve as weapons, and can inflict poisonous wounds. Many of the spines of the ordinary sea-urchin are modified into minute pincers or pedicellariae, with three jaws instead of the two of the starfish.

The pedicellariae of the sea-urchin are of several kinds. Some are "snappers," which seize and kill minute creatures attempting to settle on the skin (tridactyl type); others are "cleaners," which sweep away sandy particles that fall on the body (trifoliate type); many have bulbous heads and are armed with poison glands for use in defence (gemmiform type); one type, the ophiocephalous, has jaws resembling the head of the snake, fringed with teeth, which hold the prey until the tube feet can convey it to the mouth.

Food and Feet of Sea-urchin

The regular urchin commonly browses upon seaweed and feeds on small organisms attached thereto, and to cope with these a complicated biting mechanism has been developed. This consists of five V-shaped jaws, each carrying a long, pointed tooth that grows continuously, like the front teeth of the rabbit, and numerous plates for the attachment of masticatory muscles. The entire arrangement, when dissected, looks remarkably like an antique lantern, and is known as "Aristotle's lantern."

In a starfish or a brittlestar, tube feet are confined to the lower or *ambulacral* surface of the body, which is no more extensive than the opposite or *adambulacral* one. In the spherical sea-urchin, as also in the sausage-shaped sea-cucumber, the body is compact and almost completely covered with tube feet. In other words, the ambulacral surface has been developed extensively with great reduction of the adambulacral surface, on which is the anus. The form of the sea-urchin can be obtained from the starfish form by coalescence of the arms with the disk, and by the great development of their lower surfaces.



SEA-URCHIN. 1. Psammechinus miliaris from oral side, about natural size: a, ambulacrum; b, interambulacrum; c, gill; d, peristome. 2. Dried shell; the spines, pedicellariae, and tube feet have been removed: a, anus; b, leathery skin around anus; c, madreporic plate; d, ambulacrum; e, pores through which tube feet protrude; f, genital plate with genital pore; g, ocular plate; h, line of junction of ambulacral and interambulacral plates; j, base of spine. 3. Part of shell removed to show alimentary canal: a, ampullae at base of tube feet; b, dorsal blood vessel; c, ventral blood vessel; d, rectum; e, blood ring; f, jaw; g, lantern of Aristotle (displaced); h, mouth, surrounded by five teeth (j); k, arch; l, oesophagus, coiled intestine and rectum; m, siphon; n, fold of peritoneum supporting genital rachis; o, ovaries with oviducts. 4. Pedicellariae; A, trifoliate; B, ophiocephalous; C, tridactyl; D, gemmiform.

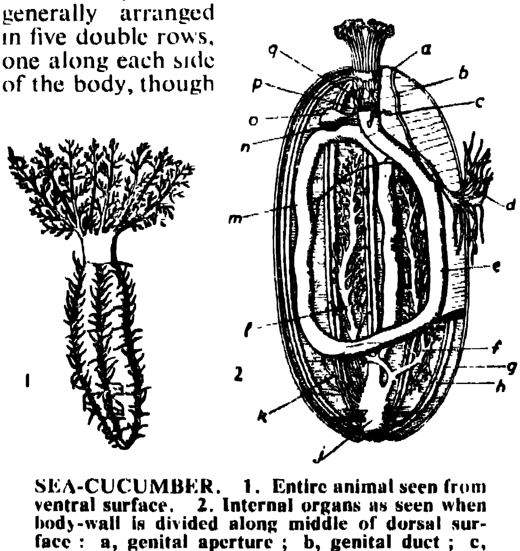
From Borradaile, Potts, Eastham & Saunders, "The Invertebrata," Cambridge University Press

So-called irregular sea-urchins are of a more specialised nature than regular urchins. One type of irregular urchin, the cake-urchin, has a centrally situated mouth and a much flattened body. These forms live at or near the surface of sandy expanses, and walk on numerous tube feet like the ordinary urchin. Aristotle's lantern is present in a modified condition, and the teeth are used for shovelling sand and mud into the mouth. Another type of irregular urchin is the heart-urchin, in which both mouth and anus are eccentrically placed. These animals dwell buried in sand or mud, through which they move, not by means of tube feet but by ploughing with much curved and modified spines. Aristotle's lantern is not present; feeding is by means of special, long tube feet which collect sand containing food organisms and convey it to short and stout tube feet which push it into the mouth.

Sea-cucumbers

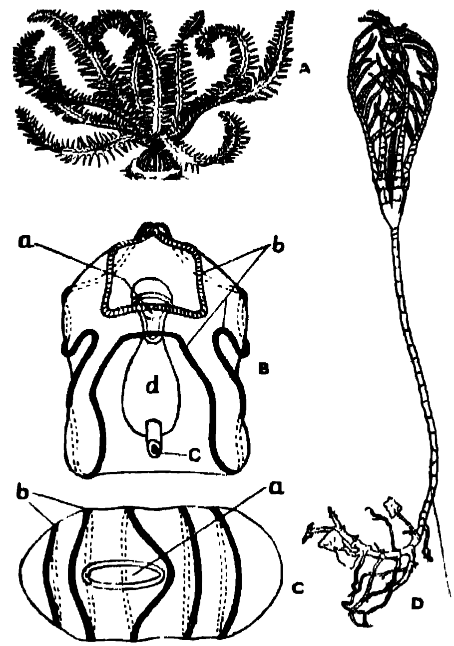
These creatures are elongated, tough-skinned, and not unlike a cucumber in form. They crawl on the sea-floor or burrow in its deposits, and are the most muscular of all echinoderms. The mouth is at one end of the animal, and is surrounded by short blunt tentacles, really modified tube feet, which serve to shovel mud into the food canal. The skin contains peculiar plates of characteristic forms, resembling anchors and wheels.

The body is five-sided, and the tube feet are generally arranged in five double rows, one along each side of the body, though they are often scattered irregularly, and maybe absent. In some forms which creep on the sea-floor there may be a well-marked distinction between upper and lower surfaces, the creeping surface comprising three of the five sides of the body. These sides correspond to the ambulacral and adambulacral areas of the sea-urchin, so that the sea-cucumber in its natural position conforms to a sea-urchin laid on its side. There is a water vascular system essentially like that of a starfish or sea-urchin, though instead of a madreporite opening to the exterior, there is an opening to the main coelonic cavity. A nerve-ring surrounds the mouth and gives off five radial nerves, which pass along the ambulacra.



SEA-CUCUMBER. 1. Entire animal seen from ventral surface. 2. Internal organs as seen when body-wall is divided along middle of dorsal surface: a, genital aperture; b, genital duct; c, madreporic canal; d, gonad; e and m, intestine; f and l, respiratory trees; g, circular layer of muscle; h, longitudinal band of muscle; j, cloaca; k, Cuvierian organs; n, stomach; o, Polian vesicle; p, ring strand of haemal system; q, ring-vessel of ambulacra system.

From Parker & Haswell, "Textbook of Zoology," Macmillan & Co



FEATHER-STAR AND SEA-LILY. A. Antedon; side-view of the free-living adult animal. B and C. Diagrams of larvae (B, auricularia; C, crinoid larva); a, mouth; b, ciliated bands; c, anus; d, stomach. D. a sea-lily, rhizocrinus: it has a jointed stalk with branching cirri by which it is rooted to the sea-floor.

From Parker & Haswell, "Textbook of Zoology," Macmillan, and Borradaile, etc., "The Invertebrata," Cambridge University Press

The alimentary canal is a cylindrical tube, which forms coils within the coelom and terminates near the end of the animal farthest from the mouth in a relatively wide chamber, the cloaca. A pair of remarkable organs open into the cloaca. These are tree-like and have the name "respiratory trees." Each starts behind as a tubular stem but becomes branched in an elaborate manner, some of the branches reaching almost to the front end of the animal. These

ramifications end in minute vesicles, through the walls of which sea water, filling the trees, passes into the coelom. The stream which passes into the body of the animal in this way conveys oxygen to the coelomic fluid, and so to the organs. In some members of the Holothuiodea the main branches of the respiratory trees have been transformed into filamentous tubes, the *Cuvierian organs*, which secrete a sticky substance that swells up in sea water and forms long silky threads. The irritated animal contracts its body muscles violently, and the pressure set up in the fluid-filled coelomic cavity tears the cloaca and expels the Cuvierian organs, as also sometimes the entire alimentary canal. If the cause of irritation is an enemy, this is entangled by the adhesive threads. Animals which have discharged their food canals immediately set about the task of re-forming (regenerating) a new one.

The sea-cucumber, like the starfish and sea-urchin, is either male or female. Early development leads to the formation of a free-swimming larva, *auricularia*.

Sea-lilies

These are creatures of the deep sea, once numerous and flourishing but now comparatively rare, and obtained only by dredging the depths of ocean. They are attached by a long jointed stalk, which bears circlets of sensitive feelers and which ends in a cup. The mouth is in the centre of the cup and is directed upwards, not downwards towards the substratum as in all other types of echinoderms. Radiating from the margin of the cup are five branching arms of feathery appearance. These are grooved above, the grooves uniting and converging towards the mouth. The grooves are traps for the fine organisms living near the sea-lily, for they bear innumerable fine cilia, which sweep currents towards the mouth.

Feather-stars

The British feather-star, *Antedon*, is a crinoid which has become free living, though it passes through an attached stage during its development. When adult, a ring of jointed projections of the aboral surface enable it to cling to objects, but it can swim by waving the feathery arms (see diagram on opposite page).

Feeding is ciliary, as in the sea-lilies. The egg of *Antedon* hatches as a minute ciliated larva, which settles and grows into a stalked larva resembling a miniature sea-lily. The upper part breaks off as the adult *Antedon*.

LESSON 20

Poor Relations of the Vertebrates

VERTEBRATES, or backboned animals, are distinguished by three important characteristics : (1) the sides of the throat are perforated by slits, called gill slits, or visceral clefts ; (2) the nervous system is a hollow tube, lying towards the back, or upper surface of the animal (the *dorsal* side) ; (3) a longitudinal supporting rod, the notochord, lies immediately below the nerve cord, and in most vertebrates forms the basis of the backbone. These characteristics are not necessarily seen in adult vertebrates, but they occur at some time during the life history of the individual.

If these characters are taken severally as criteria of relationship, the Vertebrata, or, as they are better called, the Chordata, include not only fishes, amphibians, reptiles, birds, and mammals, but also three less familiar classes, collectively called the Protochordata. These are : (1) Hemichordata ; (2) Urochordata or Tunicata ; (3) Cephalochordata.

Acorn-worm

The best-known member of the Hemichordata is the acorn-worm, *Balanoglossus*, a burrowing worm-like creature found in the sea. The acorn-worms owe their name to the shape of the most anterior of the three regions of the body. The only clear chordate character of these animals is the presence of gill slits opening from the front region of the gut (the *pharynx*) ; only a small part of the nervous system forms a dorsal tube, the rest being a diffuse layer of nerve cells and fibre bundles beneath the epidermis. There is no definite notochord (a stiff skeleton would interfere with the burrowing movements of the animal), though a short rod-like projection from the gut, anteriorly, has sometimes been homologised with the notochord ; this structure has given the class its name of Hemichordata, but as it does not underlie the short tubular nerve cord, the structure is probably not a true notochord.

Certain other hemichordates, such as *Cephalodiscus*, are small, tube-living, colonial forms, occurring in deep seas. They are of interest chiefly because the tubes of certain fossils, the *Graptolites*, are closely similar in construction, which indicates that this group was much more extensive and common in the early Palaeozoic than it is now.

Ascidians or Sea-squirts

These animals of the class Urochordata are common objects—not easily recognized as animals, however—attached to rocks and weeds on the seashore. The bag-like body is enclosed in a covering or test of tunicine, a secreted

substance chemically related to the cellulose of plants. The animal is normally distended with water, but contracts when touched by emitting two fine jets of water from small apertures near its upper end. One of these openings leads into the first part of the food canal, which is modified for breathing and feeding purposes: numerous small perforations (derived from gill clefts) conduct water through the pharynx into a cavity overlying it, and thence to the exterior, through the second opening seen outside the animal's body. The water current conveys oxygen and small organisms into the pharynx, oxygen being absorbed by the blood, while the organisms are trapped in mucus and swept along into the digestive part of the food canal.

The circulation of the blood is of interest in that the heart periodically reverses its beat, driving blood in the opposite direction. By means of this reversal of heart-beat blood is passed alternately to the gills, as in fishes, and to the viscera.

Ascidian Development

The fertilized egg of the ascidian develops into a peculiar tailed larva with a notochord which extends throughout the tail region, but is absent from the body; hence the name Urochordata. Near the upper side of the ascidian tadpole's body is a tubular nerve cord, and there are two gill clefts. After a short, free-swimming life, however, these chordate characteristics are lost during the course of swift changes constituting a metamorphosis. The tail, with its nerve cord and notochord, is absorbed completely, only a single ganglion persisting as the adult nervous system. The gill slits become multiplied in number as the pharynx rapidly increases in size. In short, the larva becomes transformed so completely that even the expert would be hard pressed to classify the adult if he knew nothing of its previous history.

Some sea-squirts are able to reproduce asexually by budding, leading to the formation of colonies of zooids in more or less close connection. Other Urochordata are not sessile but transparent animals living in the surface waters of warm seas.

The Lancelet

This animal, known to zoologists as *Branchiostoma* and also as *Amphioxus* is the commonest member of the Cephalochordata, a class of chordates in which the notochord extends through the length of the body and into the head region, and persists throughout life. It is a small fish-like creature about two inches long found burrowing in sand or fine gravel not far from the sea-shore. The elongated body is compressed from side to side and pointed at both ends, to which fact it owes the name *Amphioxus*. When feeding, the animal lies buried in sand in a vertical position, with only the tip of its body protruding. Water is drawn into the bell-shaped, jawless mouth by the action of cilia on the pharynx wall, and is expelled through numerous gill slits into a cavity surrounding the pharynx, the atrium, which opens to the exterior farther back on the body. This water current conveys minute particles of food to be trapped in the pharynx, and also serves as a respiratory current. The notochord of *Amphioxus* extends throughout the length of the body, and above it lies a tubular nerve cord of simple form. Movement is brought about by the contractions of blocks of muscles arranged alternately on either side of the notochord; the animal swims with stiff undulatory motions. The blood system consists in a series of vessels distributed round the body, and is interesting in that the blood is propelled forwards ventrally (below the gut) to the gills, and passes back dorsally, just as in the fishes and other vertebrates; in the annelids and arthropods the blood is passing forwards, dorsally.

Neoteny

During its development *Amphioxus* passes through a free-swimming larval phase which is markedly asymmetrical. The mouth first appears on the left side, while the gill slits of the eventual left side first appear on the right. This fact, and the structure of the pharynx and atrium, and the mode of feeding, have led many authorities to postulate a close relationship between the Cephalochordata and the Urochordata, the former not reaching the same stage of sessile adaptation as the sea-squirts. *Amphioxus* is very like a large and muscular sea-squirt larva, except for the greater length of the notochord; it is also, except in the possession of so many gill slits and the atrium, fish-like. This suggests that not only *Amphioxus* but also the vertebrates may have arisen from sea-squirts in which the larval characters persisted to sexual maturity, and the metamorphosis to a sessile form was suppressed.

Such a process, the development of new forms from the young stages of ancestral forms, is called *neoteny*, and appears to have been of importance in the evolution of several groups. Certain myriapods, for instance, start life with legs on only three segments, adding the rest as they grow; this suggests that the insects may have arisen from similar forms which took to breeding at the stage with only three pairs of legs, and never developed any more posterior legs. Not only the vertebrates as a whole but several groups within the vertebrates appear to be neotenous; one of the best examples is the human species.

LESSON 21

General Characters and Classification of the Craniate Vertebrates

All chordates other than the Protochordata can be grouped as Craniata, because the front end of the body is differentiated as a head, containing the brain and the organs of special sense. The craniates are the vertebrates proper, for in most forms the notochord, present in the embryo, is strengthened, and usually obliterated, by the development round it of the elements of the backbone, the *vertebrae*. The notochord extends anteriorly about half-way under the brain, not to the extreme front end. The craniates have visceral clefts, which persist into the adult stages only in the primarily aquatic classes, where they form the gills.

The Craniata must be separated into two great divisions according to whether they do or do not possess jaws around the mouth. All vertebrates with jaws (which includes nearly all the living forms) are grouped as the Gnathostomata; the remainder are without jaws and therefore are called the Agnatha. The earliest vertebrates known were jawless, but to-day the group survives only as the specialised lampreys and hags. Adult Agnatha also differ from the gnathostomes in the nature of their gills, which will be considered later.

Structural Features in Common

The further classification of the Agnatha is complicated by the fact that most of them are fossil; and it will be left until the next Lesson. The gnathostomes are divided into nine classes: one of these contains only certain extinct fish, the Aphetohyoidea. There are three classes of fishes with surviving representatives, though of very unequal numbers. The remaining four classes are tetrapods, with two pairs of terrestrial-type limbs instead of fins, and are the Amphibia, Reptilia, Aves, and Mammalia.

Though they may be superficially very unlike, all the craniates have certain structural features in common. The muscles on either side of the vertebral column are segmental, as in *Amphioxus*; though this arrangement is obscured in the adult birds and mammals, it is present in their embryos, and imposes a segmental plan on the vertebral column and on the nerves arising from the brain and spinal cord. The segmental arrangement of the muscles is an adaptation for producing sinusoidal movements of the body, which is the primitive vertebrate method of swimming. The segmentation extends into the head, but becomes obscured by the development of jaws and of the ears, so that it can be traced only by embryological studies, and by the comparison of different types.

The blood of vertebrates contains a *respiratory pigment*, which enables it to carry more oxygen than could be contained in solution by a simple fluid; this pigment, *haemoglobin*, is contained in special cells, the red corpuscles or *erythrocytes*. A few invertebrates also possess haemoglobin, but never in corpuscles. The blood circulates in the body within special vessels, the arteries and veins, being propelled by the action of a muscular heart. The blood passes forwards from the heart ventrally, as in *Amphioxus*. In fishes it goes first to the gills for oxygenation, and is then distributed to all parts of the body by arteries, being brought back to the heart by veins. In those vertebrates which oxygenate the blood in lungs there are appropriate complications of the circulatory system.

The gut of vertebrates varies in the details of its structure, according to the animal and the type of diet; with it are connected certain glands, the largest being the liver. The gut and other *viscera*, or body organs, lie in a coelomic cavity which is lined throughout by a layer of mesodermal epithelium, the *peritoneum*. The viscera are not loose in the coelom but suspended in it by *mesenteries* formed of a double layer of peritoneum enclosing connective tissue, blood vessels, and nerves. The chief excretory organs, the kidneys, lie beneath the peritoneum in the dorsal wall of the coelom. The reproductive glands, or *gonads*, are suspended by mesenteries in the coelom; the germ cells originate in the peritoneal layer. That part of the body lying behind the coelomic cavity, and therefore not containing viscera, is the tail. The anus and reproductive and excretory ducts open close together in front of the tail, often into a common chamber, the *cloaca*.

Central Nervous System

The skeleton forms a system of rigid supports to resist the pull of the muscles, and also protects the brain and spinal cord, the *central nervous system*. The skeleton first appears in the embryo as gristle or *cartilage*, but in most vertebrates the major part of this is later converted into bone. The skull consists of a box covering the brain, joined to the *olfactory* and *otic capsules*, elements covering the organs of smell and hearing respectively. The eyes lie in cups at the sides of the skull, while beneath it is a series of *visceral arches*, the skeletal supports of the wall of the pharynx, situated between the visceral clefts. There would be ten visceral arches in a complete series, but no

living animal possesses the whole set; in gnathostomes the anterior arches are modified as jaws and other structures, and the posterior ones are lost in the tetrapods.

The central nervous system arises as a plate of ectoderm on the back of the young embryo, which rolls up and sinks in to form a tube above the notochord, expanded at the anterior end, which forms the brain. The walls of the tube are much thickened by the multiplication of nerve cells, or *neurones*, but the cavity persists as the *ventricles* of the brain and a narrow canal down the spinal cord. Certain of the neurones have very long projections, the nerve fibres, which connect the various parts of the central nervous system and also connect the central nervous system with the muscles and with the sensory organs of the body. The mode of action of the nervous system is explained in the Course on PHYSIOLOGY (Vol. 2). Neurones are not confined to the central nervous system, some being situated on or among the viscera, but most neurones are in the brain and spinal cord, and it is here that their organization is most complicated.

The vertebrates are of interest not only because they include the human species but because, having hard skeletons and being relatively large, they fossilise well, and so provide more coherent evidence of the evolution of the group than do most invertebrates. It is true that there are still many tantalising gaps in the fossil record, but year by year these are lessened as new material is discovered and interpreted. Furthermore, since the Devonian period, vertebrates have been the dominant animals in most habitats, this supremacy being due to their activity, general adaptability to environment, and size.

The Lessons that follow survey the vertebrates living to-day, with some mention of their ancestors that are now extinct.

LESSON 22

Lampreys and Ancient Fishes

"FISH" is a general term which can be applied to any primarily aquatic vertebrate breathing by gills, and so can describe the Agnatha as well as the water-living classes of gnathostomes. The nature of the gills in surviving Agnatha and, as far as is known, in the fossil forms as well, is different from that in the jawed vertebrates. In the latter a respiratory current over the gills is produced by pumping movements of the whole pharynx, but in the Agnatha, the respiratory surface lines muscular pouches opening from the pharynx, and also to the exterior; the respiratory current is produced by pumping movements of the walls of the pouches, not of the actual pharynx.

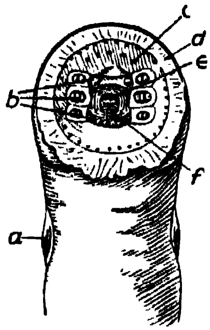
Eel-like Lampreys

Lampreys and hags (class Cyclostomata) are eel-like creatures with a jawless sucking mouth, a single organ of smell, and no paired appendages or fins. There are three British species of lamprey. The sea-lamprey, *Petromyzon marinus*, attains a length of over one yard; the brook lamprey, *Lampetra planeri*, is a small form confined to fresh water, while its relative *L. fluviatilis*, the river lamprey, lives in the sea when adult but migrates into fresh water to breed. A lamprey has a cylindrical head and trunk and a tail which is flattened from side to side. In front of and below the head is a basin-like hollow, the mouth (buccal) funnel, with horny teeth. At the bottom of the funnel is a horny "tongue," also carrying sharp teeth, and a relatively small mouth. The mouth acts like a sucker, enabling the lamprey to fix itself to the body of a fish, while the armed tongue rasps off flesh to serve as food. The organ of smell has only a single nostril, which is on top of the head immediately in front of an area of transparent skin; this is a vestigial third eye, the *pineal* organ. The paired functional eyes lie at the sides of the head, and lack eyelids, but are covered by a transparent protective covering of skin. Seven pairs of small apertures situated at the sides of the head (the first being close behind the eyes) are the gill clefts, and the region in which they occur is the branchial region. When fixed to a stone, the lamprey cannot take water in at the mouth, as does a jawed fish, but pumps water into and out of the gill apertures by muscular action. Lampreys have an interesting larva germ, the *ammocoete*, which feeds very much like the adult lancelet. The endostyle, an organ opening on the floor of the pharynx and also found in *Amphioxus*, secretes mucus in which food organisms caught up in the respiratory stream are entangled and passed into the food canal. The buccal funnel is not yet formed, and the rudimentary eyes lie under the skin. Ammocoetes live in mud, tail upwards and there are light-sensitive organs in the tail. If these are stimulated, the ammocoeta wriggles and either moves away or buries itself further.

Marine Hags

The hags are marine forms which, like the lampreys, are predatory on fish; their habit of eating their way into the body of the victim has given rise to the idea that they are parasites, but this is not really so.

The earliest fishes known in any detail are found in Silurian and Devonian rocks, and are for the most part clumsy, bottom-living forms with a heavy armouring of bony plates. Broken pieces of similar bony plates are found in certain Ordovician rocks, the earliest traces of vertebrates which have been found. These fish, of the class Ostracodermi, are without jaws. They probably fed on mud, as the larval lampreys do to-day. The head was covered by an almost continuous sheet of bone, the rest of the body was heavily scaled, and there was a single pair of scaly fins just behind the head in some forms, though not in others. It appears that the gills were pouched. These fishes, and all the other earliest fishes, lived in fresh water, a fact which might be deduced, without the fossil evidence, by the structure of the kidneys in vertebrates, which besides being the organs of nitrogenous excretion are admirably formed for bailing water out of the body. The problems of *osmotic regulation* affect a metazoan animal living in fresh water just as they do a protozoan.



RIVER LAMPREY. Ventral view of the head of Lampetra fluviatilis: a, eye; b, teeth of buccal funnel; c, buccal funnel; d, papillae; e, mouth; f, tongue.

From Park & Haswell, "Textbook of Zoology," Macmillan

Aphetohyoidea

Other fish found mostly in Devonian rocks are of interest in that they show a condition of the jaws intermediate between the other gnathostomes and the Agnatha. These fish belong to the class Aphetohyoidea, sometimes called Placodermi owing to the heavy bony armour of some forms. Many of these fishes looked superficially like modern fishes, and had characteristic spiny fins. They had jaws, but whereas in all other gnathostomes the visceral arch immediately behind the jaws (the *hyoid* arch) either supports the jaws or is part of the ear apparatus, in the Aphetohyoidea the hyoid arch was an ordinary gill arch like the ones behind it. Such fishes represent an early stage in gnathostome evolution, and were superseded by other fishes with more efficient jaws. The last aphetohyoidean, *Acanthodes*, lived in coal swamps and became extinct in the Permian.

Chrondrichthyes

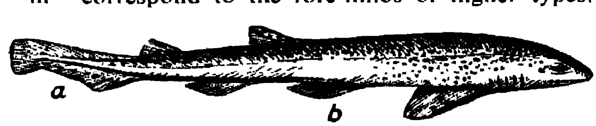
The fish of this class are peculiar in that they never develop bone, the skeleton remaining cartilagenous, sometimes strengthened by limy deposits. They are not, strictly speaking, ancient fish, in that they first appear in the fossil record in the late Devonian, after the other classes of fish were already established, but they are considered in this Lesson as a matter of convenience.

The most familiar cartilagenous fishes are the sharks and rays, of the sub-class Selachii; members of the other sub-class are rare. The class as a whole is sometimes called the Elasmobranchii, because the gills are strap-like rather than filamentous as in the bony fishes.

Dogfish

Since their first appearance the selachians have been fairly large, predaceous fishes, showing little variation in structure, except a tendency to become flattened and bottom-living. The dogfish, *Scyliorhinus*, is a small shark. The dogfish illustrated shows, at the side of the head, five slits, which are the gill slits, not covered by a common operculum, though each has a flap of skin acting as a valve. Behind the eye is another opening, the *spiracle*, which is all that remains of the gill slit in front of the hyoid arch; it is restricted in size because the upper skeletal element of the hyoid arch, the *hyomandibula*, forms a prop between the brain case and the back of the jaws. The upper jaw is otherwise attached to the brain case only by ligaments, a condition known as a *hyostylic* jaw suspension. The surface of the dogfish's body is rough and prickly when stroked from the tail towards the head. This is due to the presence in the skin of numerous tooth-like elements, *dermal denticles* (sometimes called placoid scales). Each denticle consists of two parts, a basal plate of bone-like material and a superficial spine coated with the substance (enamel) which covers the teeth of higher animals. The denticles are admirably shown in a commercial preparation of shark skin (shagreen). The teeth of the shark are modified placoid scales arranged in regular rows in the mouth and on the lips. Such teeth are continually replaced, as they break off, by younger growing teeth within the mouth cavity. The teeth and the spines of the scales contain a cavity in which blood circulates, carrying food materials to the denticles.

The dogfish's body is streamlined and well adapted to active swimming. The paired *pectoral* fins lie close behind the head. They correspond to the fore-limbs of higher types.



DOGFISH (Scyliorhinus canicula): a, lower lobe of caudal fin; b, right pelvic fin.

From Borradaile, "Manual of Elementary Zoology," Oxford University Press, Hodder & Stoughton

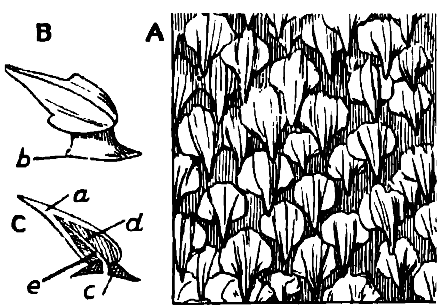
The hinder paired fins, *pelvics*, which are the homologues of the hind limbs of land animals, are smaller and lie just in front of the cloaca, the common opening of the gut and excretory and reproductive ducts. In males they are united in the middle line and bear each a grooved rod, the *clasper*, a copulatory organ. Two single fins lie on the back, these being the fore and hind *dorsal fins*; one lies on the under side, the *anal fin*, and another follows the outline of the tail. This last, the *caudal fin*, has two lobes, and the tip of the tail passes into the upper lobe. Such a fin is different from that of the bony fish, and is given the name *heterocercal*.

When a Fish Swims

The heterocercal type of tail is a primitive character in fishes, and occurs in all the groups of early fish; it has certain disadvantages (explained below) and becomes modified to a symmetrical fin in most modern fish. The illustration shows a surviving heterocercal tail, of a sturgeon, and one of the types of symmetrical tail (the *homocercal*) which has been derived from the more primitive type.

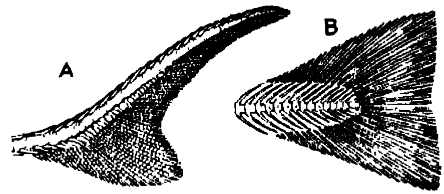
When a fish swims, successive contractions of the segmental muscle-blocks throw the body into a series of sinusoidal waves which pass down the body from head to tail. As each part of the flank moves, it meets the resistance of the water at an angle to the antero-posterior axis, and the result is that the fish moves forward, in the same way that a boat moves forward when propelled by a scull over the stern. The wave motion of the body is best seen in long and narrow fish like eels; but the principle is the same in all fishes, with a few exceptions where the fins have taken over the swimming functions. In normal fishes the fins act as stabilisers to prevent rolling or pitching, and are used in braking and steering.

The heterocercal tail, with a fin lobe below the upturned axis of the body, is so shaped that



PLACOID SCALES. A, portion of the skin of the dogfish as seen under a lens; B, a single scale removed from the skin; C, the same in section (diagrammatic); a, enamel; b, base of the scale; c, the same in section; d, dentine; e, pulp cavity.

From Borradaile, "Elementary Zoology"



CAUDAL FINS. Diagrams showing structure of caudal fins: A (heterocercal), sturgeon Acipenser sp.); B (homocercal), haddock (Gadus aeglefinus).

From Norman, "History of Fishes," Ernest Benn, Ltd

during swimming the action of the fin tends to push the head of the fish downwards. In sharks this tendency is counteracted by the elevating action of the large and flat pectoral fins, which are held below the body at an angle to the horizontal and tend to lift the front end of the fish upwards. The actions of the tail fin and pectoral fins therefore balance each other and the fish swims level in the water. A symmetrical tail does not affect the angle of the fish in the water, so where there is a homocercal (or other symmetrical) tail, the pectoral fins are not needed in maintaining a level course and can be better used for other purposes; all the fastest swimming fish have homocercal tails. The streamlining of the body-shape reduces to a minimum the resistance offered by the water to forward progression.

Rays and Skates

The selachians have no air-filled swim bladder, as have most bony fish, and their specific gravity is therefore greater than that of water. When such a fish stops swimming, it sinks. In these circumstances it is not surprising that there should be a great development of bottom-living forms among the selachians, many of which have become flattened. A familiar example is the ray, which is a food-fish of economic importance. The skate is a species of ray, *Raia batis*. The tail is thin, the bulk of the rhomboidal body consisting of the expanded pectoral fins; it is the fins which are eaten. Swimming is by undulatory movements of the fins, not of the body axis. In spite of their bottom-living habits, rays can be quite active and can catch fish as well as eating the invertebrates to which their flattened, crushing teeth seem best adapted.

When a ray is resting on the bottom, the mouth, being on the lower surface, is not favourably placed for taking in water needed in respiration. Accordingly, water enters the pharynx by way of the spiracle, which is more suitably placed on top of the head, leaving the pharynx through the gill slits located on the lower surface of the head near the mouth. The spiracle is more important in rays than in

dogfish, which are better able to draw water into the mouth. The electric ray, *Torpedo*, which is sometimes caught off the British coasts, is capable of giving a powerful electric shock if handled ; it stuns its prey by this means, as well as using it in defence. The electricity is produced in a pair of electric organs near the head, which are formed of modified muscles. Ordinary rays also have electric organs, in the tail, but not powerful enough to shock a man handling them.

With a few exceptions, all selachians, fossil or living, are marine ; indeed, the group is specially adapted in a curious way to life in the sea. The early fishes were fresh-water forms, and would therefore have to combat the continual entry of water into their bodies. The osmotic pressure of the blood of most fish is about half that of sea water, so that a fish in the sea has another problem, that of preventing water loss from the body. The selachians have solved this problem in a unique manner; counting only the salts in it, their blood has about the same concentration as that of other fish, but in addition to the salts, selachian blood contains *urea* in such a quantity as to bring the total osmotic pressure up to that of sea water. Urea is a product of nitrogenous excretion, normally excreted by the kidneys, and such a blood-concentration of urea as is normal to a selachian would be toxic to any other vertebrate. The urea is reabsorbed in the selachian kidneys and there is a mechanism for the adjustment of the amount absorbed so as to maintain the blood osmotic pressure equal to that of the surrounding sea water. Some selachians enter fresh water (perhaps 50 species out of some 5,000 living forms) and are able to lower the level of blood urea when they do so.

"Mermaids' Purses"

The eggs of elasmobranchs contain large reserves of food yolk used by the developing embryo, and are enclosed in horny pillow-shaped cases known as "mermaids' purses." Each corner of the case has either a short horn or a cluster of twisted threads projecting from it. These serve to fix the egg-case firmly in crevices or attach them to seaweeds until the young animal hatches out, which is a matter of several months. The young, on hatching, resembles its parents and soon begins to feed. *Viviparity*, or live birth, is quite common among the selachians.

LESSON 23

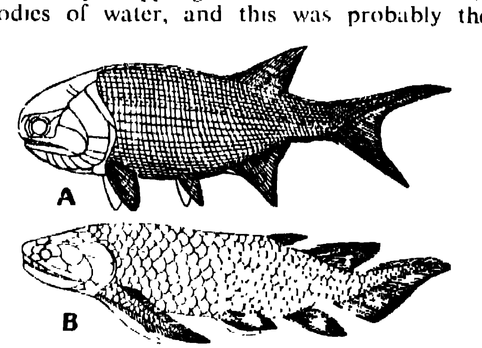
Bony Fishes

Two classes of fish, which are nowadays of very unequal importance, remain for consideration. One, the Actinopterygii (the ray-finned fish), is represented to-day by some twenty thousand species of the order Teleostei, the familiar bony fishes, and by a few archaic survivors such as the sturgeons. The other class, the Choanichthyes (fish which have an internal nostril) has two orders ; one, with only a single rare survivor, gave rise to the Amphibia in the Devonian age ; this is the order Crossopterygii. The other order, the Dipnoi, survives as three genera of lung-fish.

The early members of both classes looked very similar, having heterocercal tails and a covering of heavy, shiny scales. The detailed structure of the scales was not the same in the two classes, though both had a bony base and a superficial covering of inorganic material resembling the enamel of teeth, though it was not actually enamel. Later forms in both classes have lighter scales which retain only a bony layer.

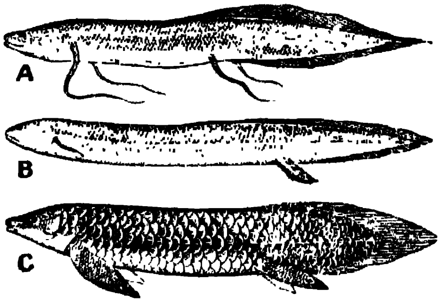
During Drought

It is probable that in the Devonian age all these bony fishes possessed paired lungs which they could use as an accessory breathing apparatus, just as the Dipnoi to-day breathe aquatically by gills when the water is well aerated, but can breathe atmospheric air in the lungs if the water become stagnant. Areas of the north of Scotland, where these fishes are found, show evidence of having been, in the Devonian, a tropical, swampy region such as the lung-fishes inhabit to-day. During a drought, fishes with lungs might be able to survive by wriggling across land to find other bodies of water, and this was probably the



RESTORATIONS of (A) a primitive actinopterygian, with one dorsal fin and the paired fins without muscular bases, (B) a crossopterygian, with two dorsal fins and paired limbs which are muscular lobes. Both are Palaeozoic. Note that both have a heterocercal tail.

From J. R. Norman, "A History of Fishes," Benn, Ltd.



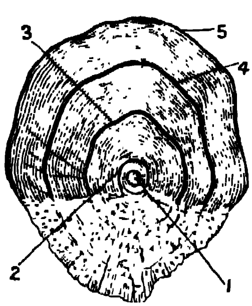
DIPNOI. A, African mud-fish (Protopterus); B, South American lung-fish (Lepidosiren); C, Australian lung-fish (Epiceratodus).
From J. R. Norman, "A History of Fishes," Ernest Benn, Ltd.

stimulus which led to the transformation of the paired fins into limbs, and so of fishes into amphibians.

There is little doubt that in the Devonian the amphibians arose from some line of crossopterygian fishes, though it is not certain which line. The crossopterygians which had not become amphibians declined after the Devonian, and the only living survivor is of a line which left fresh water and took to the sea; this, the *Coelacanthini*, is known by fossil forms from the Carboniferous to the Cretaceous, and to-day only by the rare *Latimeria*, occurring off the east coasts of Africa. The other order of Crossopterygii, the Dipnoi, are found in the same deposits as their relations mentioned above, and to-day in similar hot and swampy environments; they were never an important group, but they are extremely well adapted to their particular environment.

Lung-fish

The living Dipnoi are shown in the accompanying illustration. *Epiceratodus* is the Burnett salmon of Queensland, and occurs only in two rivers of that part of Australia. It grows to about four feet long, and breathes air when the water is stagnant, though it cannot survive complete dessication. *Protopterus* and *Lepidosiren* are similar to one another in appearance and in their habitat, which is in swamps, *Protopterus* widely distributed in tropical Africa, and *Lepidosiren* in the Amazon basin and Paraguay; these forms are able to survive the drying out of the swamps by burrowing in the mud and remaining inactive, but breathing air, until the water returns. Blood can be sent, for oxygenation, either to the gills or to the lungs, the anatomical arrangement resembling that of larval amphibians.



SALMON SCALE. Cycloid scale from large spring-fish; 1 and 2 show two years' river life; 3–5, three years' sea life.
From Norman, "A History of Fishes"

The Actinopterygii

This class is divided into three orders, on skeletal characters, each order representing a grade of organization on the way to becoming more efficient fish. Each order shows an *adaptive radiation*, that is, a variety of forms develop, adapted to different habitats, and the two earlier orders were, in turn, superseded by the next order. The oldest, or Palaeonisciformes, though they first appear in the fossil record later than the earliest Choanichthyes, had by the end of the Devonian become the dominant fishes of fresh water and had also begun to live in the sea.

They remained dominant until ousted by their own descendants, of the order Holostei, in the Mesozoic. Of the first order, only the sturgeons and spoonbills, and the birchir of West Africa (*Polypterus*), survive. The Holostei were also both fresh-water and marine, but now survive only in two fresh-water American genera, *Lepidosteus*, the gar-pike, which retains the shiny scales, and *Amia*, the bow-fin. From the Cretaceous onwards the Teleostei, descendants of the Holostei, radiated rapidly, became very numerous, and replaced the older types of fish

The Air Bladder

The lungs of ancient fishes are in the teleosts replaced by a single air bladder; *Polypterus* still has paired lungs. The air bladder is a hydrostatic organ, the possession of which enables a fish to adjust its specific gravity (by altering the quantity of air in the bladder) to equal that of water; the fish need not then expend energy in swimming merely to keep afloat. The more primitive teleosts, such as the herrings and the common fresh-water fishes (the Ostariophyst) such as roach, tench, minnows, or catfish, have a duct leading from the air bladder to the fore part of the gut, and can gulp air through the mouth, or expel it, to adjust the pressure in the air bladder. The more advanced teleosts, chiefly those which have spiny fins (the Acanthopterygii) such as perch or wrass or gurnards, have lost this duct, and change the amount of air in the bladder by secretion of gases from the blood through special organs in the wall of the bladder.

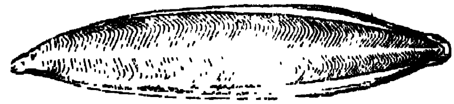
Certain species of Teleostei lose the air bladder altogether: these are either shore-living (certain Blennies), bottom-living (the flat-fish such as plaice and soles), or strong swimmers which nevertheless rest on the bottom when not swimming, as the common mackerel lies at the bottom of the English Channel during the

winter. In the latter case, the loss of the air bladder is an advantage in freeing the fish from the injurious effects of a rapid change of pressure as it moves from one depth to another ; fishes with an air bladder, if hauled quickly from a depth, explode owing to the expansion of the gas in the bladder as the water pressure lessens. In the Ostariophysi, mentioned above, the air bladder also acts as a resonating organ for the ear, and such fish have excellent hearing. The bladder may also be used to produce sounds, as it is in some species of catfish and in the gurnards.

The teleosts have *homocercal* tails : in the more advanced forms the pectoral fins are high on the sides of the body while the pelvis fins have moved forward under the throat, even anterior to the pectorals. This is a device to prevent the fish rising in the water when it brakes, and so gives greater control of swimming movements. Rapid swimming in teleosts is effected by the body muscles just as in a dog-fish, but fin movements may be used for slow swimming. The scales of teleosts are usually thin, overlapping bony plates embedded in the skin ; a common shape is the *cycloid* or rounded type shown in page 2074. Some fish lose the scales (as do the eels) while others develop a stiffer bony armour as does the sea-horse or its British relative, the pipe-fish.

Growth of Scales

Examined under the microscope, scales reveal the age of a fish. This is because the scales are constant in number, and must grow in order to cover the increasing surface of the growing fish. Each scale is marked with a number of concentric rings, resembling the rings of growth shown in a cross-section of a tree. Like the tree, the fish grows more rapidly during one season of the year than during another. Spring and summer are times of plenty and the fish grows more rapidly then than at other times. The scales grow with corresponding rapidity. In autumn and winter growth slows down and may ultimately cease. So also does the growth of scales. The result is that close rings (of winter) alternate in the scale with wider rings (of summer), and a count of the close rings indicates how many winters the fish has lived through. Age determination can be made also by examination of small limy concretions found within the ear cavity and used as agents of balance, for these ear-stones, or *otoliths*, also show alternate zones of summer and winter growth.



LEPTOCEPHALUS, the larval form of the European fresh-water eel.
From Norman, " A History of Fishes "

The gills of bony fishes lie under a common flap of skin, strengthened with bone, the *operculum*, in contrast with the selachians, which have no operculum. The mechanism for maintaining a flow of aerated water from the mouth out over the gills is essentially similar, with valves to ensure a one-way flow, but in the teleosts the spiracle is lost. Though the air bladder has lost its ancient respiratory function, it is of interest that many teleosts, especially tropical forms living in water liable to become stagnant, have given up gill breathing and are able to utilise oxygen from the air, taking it in through a variety of specially modified respiratory surfaces ; an example is the Siamese fighting fish, *Betta*, which has a well-vascularised organ opening from the pharynx, or certain tropical catfishes which have a respiratory surface in the intestine, and swallow air. Such fish are obviously suitable for keeping in domestic aquaria.

Many fish perform long migrations in order to breed. A familiar example is the journey of salmon and sea-trout up rivers to lay their eggs in the shallows of the river-head. Eels have a contrary migration, going to the sea to breed, then returning to fresh water.

Ocean-going Eels

The larva of the common eel was long unrecognized, and was given a different name, *Leptocephalus*, because it was regarded as belonging to a different group of fishes. It is a glassy, leaf-like creature, very much flattened from side to side. The story of the European eel was elucidated by Dr. Johannes Schmidt, who tracked the leptocephali on their extensive journey across the Atlantic. Mature eels migrate across the bed of the ocean and spawn in its western part, south-east of Bermuda. The leptocephali hatch out in the spring and travel in the Gulf Stream towards the shores of Britain. They spend two years in travel, and arrive on this side of the Atlantic about three inches in length. They then undergo transformation—becoming smaller and more slender—into elvers, which ascend the rivers, where they seek ponds and there grow to maturity.

LESSON 24

Amphibians

Some classes of the vertebrates are very well defined: you recognize mammals by their covering of hairs; you identify birds by their feathers.

The amphibians and reptiles are not easy to distinguish at first sight, for the essential difference between them concerns the life-history. Amphibia must breed in water (with a few exceptions where curious modifications have arisen to avoid this), whereas reptiles lay eggs able to develop on dry land. Amphibia typically have larval stages which live in water, breathing by gills, while the reptiles hatch as miniature adults, breathing air. Most Amphibia have moist skins, from which there is a great deal of evaporation, so that the animal is liable to lose too much water unless it keeps to a moist habitat; reptiles have dry skins and can be very economical of water. In short, the Amphibia are less perfectly adapted to terrestrial life than are the reptiles.

Distinguishing Characteristics

The Amphibia are readily distinguished from any of the fishes because they have limbs with toes, primitively five on each. Such a limb is called *pentadactyle*, and is the basic tetrapod type. The bones correspond in fore and hind limbs. The upper element is single, the humerus in the fore-limb, the femur in the hind. Then follow two bones, the radius and ulna in the fore-limb, the tibia and fibula behind. The wrist and ankle bones are arranged in two rows, with one or more small bones also between them; they are the carpals in the wrist and the tarsals in the ankle. The hand and foot bones are five metacarpals and metatarsals respectively, to which are attached the phalanges, or bones of the fingers and toes.

The first Amphibia arose from crossopterygian fishes in the later Devonian period. Such forms bear an extremely close resemblance to some contemporary fish in the structure of the skull, and some very early ones had scales and even a tail fin. The limbs were pentadactyle, however, and the hyomandibular bone of the fish (the uppermost element of the hyoid arch) had been incorporated into the newly developed *middle ear*, instead of propping the jaw. In fishes, the only part of the ear present is the *labyrinth*, within the skull, a series of canal and chambers with sensory surfaces inside, parts of which are sensitive to sound, parts to the pull of gravity or to changes of orientation in space.

Sound waves reach the labyrinth, or *inner ear*, through the bones of the skull. In mammals there is an *outer ear*, or *pinna*, whose function is to concentrate sound waves on to the ear drum, which is a vibratile membrane stretched across a hole in the skull. From the ear-drum the vibrations are conveyed by a chain of three small bones to the labyrinth, across the middle ear. In amphibians, reptiles, and birds, instead of the three bones as in a mammal, there is only one bone in the middle ear, performing the same function; this bone is the *stapes*, derived from the *hyomandibula* of the crossopterygian fish. There is no outer ear in the non-mammalian tetrapods. The spiracular gill opening is lost in the Amphibia, but the middle ear does open into the pharynx, by the *Eustachian tube*, not homologous to the spiracle but occupying a similar position.

Extinct Amphibians

The fossil amphibians are grouped as the Stegocephalia, not an order but an inclusive term for a group of orders with heavy bony armour on the head. Such forms are typical of the coal-swamps of the Carboniferous, during which period they gave rise to better-adapted land-living forms, the reptiles. The Carboniferous and Permian Stegocephalia may be quite large, and the later forms became flattened, apparently taking again to a wholly aquatic life. They then died out, and are survived by smaller types; the three modern orders are probably derived from different ancient orders. Of the modern forms the Anura or frogs are the most interesting; they were already present in the Jurassic, and probable tailed ancestors can be traced into the Carboniferous.

Present-day Amphibia

These are grouped in three orders: the Apoda, which are limbless; the Urodela, or tailed amphibians; the Anura, or tailless amphibians. *Ichthyophis*, illustrated in page 2077, a worm-like amphibian which lacks limbs and tail, forms an example of the first order; newts and salamanders belong to the second order; and frogs and toads are included in the third order. The Apoda are not of especial interest. They are widely distributed in the tropical regions of both hemispheres, where they are found burrowing in damp earth.

Most country-dwellers are familiar with the little efts, or newts, commonly seen in ponds or ditches, or crawling over the damp ground. In appearance they are not unlike lizards, but their movements are more sluggish, and the slimy, scaleless skin and the clawless digits at once show them to be amphibians. Newts lay their

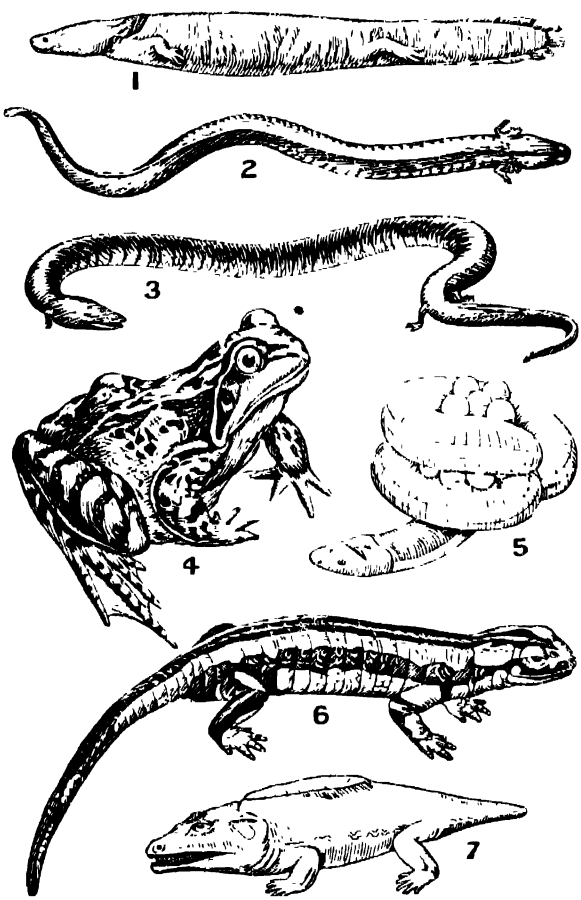
eggs in water, and tadpoles hatch out from them. These larvae possess filamentous gills, which sprout out from the sides of the throat, and, later, gill clefts, which open to the exterior by an opercular aperture, as in bony fishes. In the adult the gill filaments have disappeared and the gill clefts have closed. There are exceptions, which will be mentioned later.

Salamanders

Salamanders resemble newts, but are mostly larger. When adult, they are better suited to life on land. The spotted salamander, *Salamandra maculosa*, common in damp woods in parts of central Europe, is of striking colour, being black with orange markings. In such terrestrial urodeles the limbs stand out from the trunk, and the soles of feet and hands are pressed close to the ground with the digits directed forwards.

With a solitary exception, all the members of the sub-order containing newts and salamanders (Caducibranchiata) have functional eyes provided with movable eyelids. This exception is *Amphiuma*, an eel-like creature with greatly reduced limbs, which lives in the ditches of rice-fields in North America. Closely related to this creature is *Cryptobranchus*, one species of which, *C. japonicus*, is the giant salamander of Japan. This amphibian, which lives in mountain streams, is the largest living form known, attaining a length of five feet.

Another sub-order of the Urodela, the Perennibranchiata, contains forms with three pairs of fringed external gills which spread out transversely from the side of the throat. *Necturus*, the mud-puppy, with species living in the Mississippi basin and the Canadian lakes, a voracious nocturnal creature, belongs to this group. It has functional eyes covered with thin folds of transparent skin, four fingers, and four toes, and two gill clefts. Another member of the group is *Proteus*, a European form which lives entirely in the subterranean waters of caves. The eyes of this creature are completely hidden beneath folds of opaque skin and are degenerate. It has three fingers and two toes, and white or pinkish skin, which, if subjected to light, develops pigment and becomes black.



TYPES OF AMPHIBIA. 1, Necturus (Perennibranchiata) or mud-puppy. 2, Siren (Sirenoidea) o mud-eel. 3, Amphiuma (Caducibranchiata). 4, Frog (Anura). 5, Ichthyophis (Apoda) 6, Salamandra (Caducibranchiata). Nos. 1-3 and 6 belong to the order Urodela. 7, Reconstruction of Cacops (Stegocephalia) : this form is allied to the primitive reptiles.
1–6, *from Parker & Haswell, "Textbook of Zoology," Macmillan*

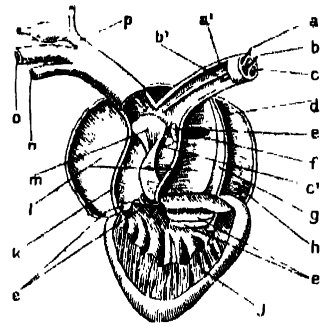
Mud-eels

The third sub-order of the Urodela, Sirenoidea, contains forms with persistent gills and lidless eyes, but with fore-limbs only, the hind limbs having disappeared. To this group belongs *Siren*, the mud-eel, which occurs in the southern U.S.A. The fore-limb is short and has three or four digits, and the toothless jaws have horny sheaths. The animal lies buried in the mud of ponds and ditches, occasionally crawling over the ground, or swimming.

Frogs and Toads

Frogs and toads (Anura), the most successful of all amphibians, occur in almost every part of the world and their structure is familiar. The common frog, *Rana temporaria*, has a short, tailless body with disproportionately long limbs, characteristics associated with the leaping habit. The frog is also an expert swimmer, and the hind feet are webbed. Frogs execute movements closely resembling those of the human swimmer, but the fore-limbs take no part in aquatic progression, being folded on the breast.

The skin is moist and soft, being kept in this condition by numerous glands, which lie immediately beneath it and open on to its surface, discharging quantities of mucus from time to time. Frogs—and, in fact, all tailless amphibians—breathe solely by means of lungs and the skin; the gills and gill slits of the tadpole are entirely lost in the adult. At first the newly hatched and limbless tadpole breathes by three pairs of plume-like gills, much like those of the mud-puppy, *Necturus*. Later on these are replaced by so-called "internal" gills, vascular folds on the walls of gill slits, which place the cavity of the throat in communication with the exterior. A fold then grows back over the external gills (now shrivelling up) and the gill slits, the edge of which fuses with the body wall, except at one point on the left side, where a small round opening remains. Through this passes water which has entered the mouth, traversed the gill slits and bathed the gills. The lungs, growing out as pouches from the back of the mouth floor, gradually supplant the gills as these dwindle and disappear, and as the gill slits close. These alterations involve profound changes in the heart and blood vessels.



HEART OF A FROG, from the ventral aspect, with the cavities laid open; a, a¹, bristle in left carotid trunk; b, b¹, bristle in left systemic trunk; c, c¹, bristle in left pulmo-cutaneous trunk; d, aperture of pulmonary veins; e, e, valves; f, sinu-auricular aperture; g, auricular septum; h, left auricle; j, ventricle; k, conus arteriosus; l, right auricle; m, longitudinal valve; n, pulmo-cutaneous arch; o, systemic arch; p, carotid arch.
From Parker & Haswell, "Textbook of Zoology," Macmillan

In a tadpole, the heart agrees in essentials with that of a fish, consisting of two principal chambers: an *auricle*, which receives the impure blood of the body, and a muscular *ventricle*, which pumps it to the gills for purification, and on to the tissues of the body. The auricle becomes divided by a fleshy partition into two chambers, right and left auricles. Both chambers open into the ventricle, which remains undivided.

Visceral Arches

The gill system of a fish is related to six visceral arches. The first and second are the mandibular and hyoid arches, the last four are branchial arches. Each arch is supplied by an artery (the afferent branchial) which branches from the main vessel or ventral aorta from the heart. Blood in the afferent branchial arteries passes through blood capillaries in the filaments of the gills, after which it is collected by another set of arteries, the efferent branchials; these unite to form the dorsal aorta in the roof of the throat.

In the tadpole, of Urodela as well as Anura, the first two visceral arches are not concerned with oxygenation of the blood, the four branchial arches alone being functional in this way. The efferent branchial arteries leading out of these arches join to form two main vessels, which unite behind into the dorsal aorta, but have arterial extensions in front leading to the head. At metamorphosis, when the lungs function, changes occur in these arteries. As the gills atrophy, their capillaries disappear, so that afferent and efferent arteries become continuous. The first branchial artery becomes the *carotid* arch, carrying blood to the head; the second becomes the *systemic* arch, conveying blood to the body generally; the third branchial artery disappears completely; and the last branchial artery forms the *pulmo-cutaneous* arch, along which blood passes to the lungs and skin. These are the three channels leaving the ventricle which can be traced in the illustration of a frog's heart. The piece of artery connecting the first two branchial arches of the tadpole becomes closed and persists as a fibrous strand, the *ductus caroticus*. One reservation must be made for the majority of Urodela, in which, alone of all four-footed animals (tetrapods), is a third branchial artery.

The right auricle receives three large veins, paired *superior vena cava* (draining blood from the head, fore-limb, and skin) and a single *inferior vena cava* (bringing blood from the liver and the kidney). Connected with the latter are two important systems of veins, the *hepatic portal system*, developed in connexion with the liver, and the *renal portal system*, associated with the kidney. Blood from the hind limbs, which has already passed through one set of capillaries, must pass by one of these channels in order to reach the heart. In doing so it must pass through a second set of capillaries in the one organ or the other. The term *portal system* is given to veins which terminate at both extremities in capillaries.

Blood and the Liver

Blood from the dorsal aorta passes to the digestive canal by a number of branches from a single artery, the *coeliaco-mesenteric*. These various branches pass to the stomach and intestine, in the walls of which they break up into capillaries. Digested food materials are absorbed into the blood contained within the capillaries, which is collected into larger and larger veins, ultimately forming the single hepatic portal vein. One of the functions of

the liver is to remove food materials from the blood for storage until required. The hepatic portal is the channel along which blood proceeding to this storehouse is carried. When blood leaves the liver it flows out by a pair of hepatic veins, and these join the inferior vena cava.

The left auricle receives blood from the pulmonary veins, which has been oxygenated in the lungs. Blood from the right and left auricles mixes in the ventricle, so that in the Amphibia there is not the complete separation of oxygenated and de-oxygenated blood in the heart, which occurs in mammals and birds. This does not matter much to a frog, because the skin is as important a respiratory organ as the lungs ; blood reaches the skin by a special *cutaneous artery* branching from the pulmonary artery, but returns to the right auricle.

Curious Toads

An interesting form is *Pipa*, the Surinam toad, of Brazil. In the skin of the female's back small pouches provided with lids are developed, and in these the eggs are deposited, here to remain throughout development and until metamorphosis.

Xenopus, the South African clawed toad, is aquatic throughout its life history, though the adult is of the ordinary anuran form.

Not all toads have a thickset frame and warty appearance ; since, in addition, some frogs have this appearance, such characteristics are not diagnostic. But most toads are terrestrial, and some burrow in the ground. They are nocturnal hunters, which kill large numbers of snails and other harmful creatures ; hence they are not the pestilential nuisances some superstitious people believe them to be. Among other evils, they have been supposed to spit venom, to suck the udders of cows, and to poison milk kept in cellars ; these reports are, of course, fanciful. *Nectophrynoides*, an East African toad, is viviparous.

Edible and Tree Frogs

The large green edible frog, *R. esculenta*, occurs commonly on the Continent. With one exception (*Rhacophorus*, the flying frog), all the species of the frog family (Ranidae) found in North America, Europe, and Asia belong to the one genus, *Rana*. The greatest number of genera occur in Africa and the Indo-Malayan countries. *Rhacophorus* lives in tree-tops in Japan, India, Malaya, and N. Australia. Both fingers and toes are strongly webbed, and their terminal joints are provided with adhesive disks. These characteristics enable the animal to glide considerable distances in a slanting direction and to hold on to the foliage of trees.

Tree frogs proper (Hylidae) occur in South America, with a few species in Europe and Asia, but not in Africa, India, or Malaya. Typical members of the family have finger disks, and green is the usual colour, though most forms have the power to change their colour when necessary. Most of them lay numerous eggs in long strings, which are attached to various parts of the body. Some tree-frog mothers construct nests in which to deposit their eggs, the most remarkable being that of *Hyla faber*, the South American ferreiro. The female builds a circular mud wall in the shallow part of a pond, and in this the eggs are laid.

LESSON 25

Reptiles

Reptiles, birds, and mammals have certain common characteristics which mark them off from other vertebrates. The most important constant feature of all three classes is the development in connexion with the embryo of two structures, known as foetal membranes. These are the *amnion*, which is wrapped round the embryo and serves to protect it, and the *allantois*, which is an embryonic respiratory organ. These two characteristics justify the use of the term Amniota to denote birds, reptiles, and mammals, as distinct from fishes and amphibians.

Reptilian Characteristics

In reptiles the skin gives rise to distinctive structures of an exoskeletal nature in the form of scales. The skull moves on the first vertebra about a single bony projection or occipital condyle. The skeleton of the lower jaw is built up of five or six separate bones, and this jaw is articulated with the quadrate bone of the skull. The heart consists of two auricles and a ventricle which is usually partially, sometimes completely, divided into halves by a septum, so that two more or less complete ventricles are formed. Functional gills are never developed at any stage, though vestigial gills, or visceral clefts, occur during development. As in Amphibia, however, the terminal part of the alimentary canal and the ducts of the reproductive organs open into a common chamber or *cloaca*, through which eggs and sperms as well as faecal matter must pass in order to reach the exterior.

Reptiles, unlike birds and mammals, have a blood temperature approximating to that of the animal's surroundings. Like amphibians and fishes, they are "cold-blooded." Reptiles

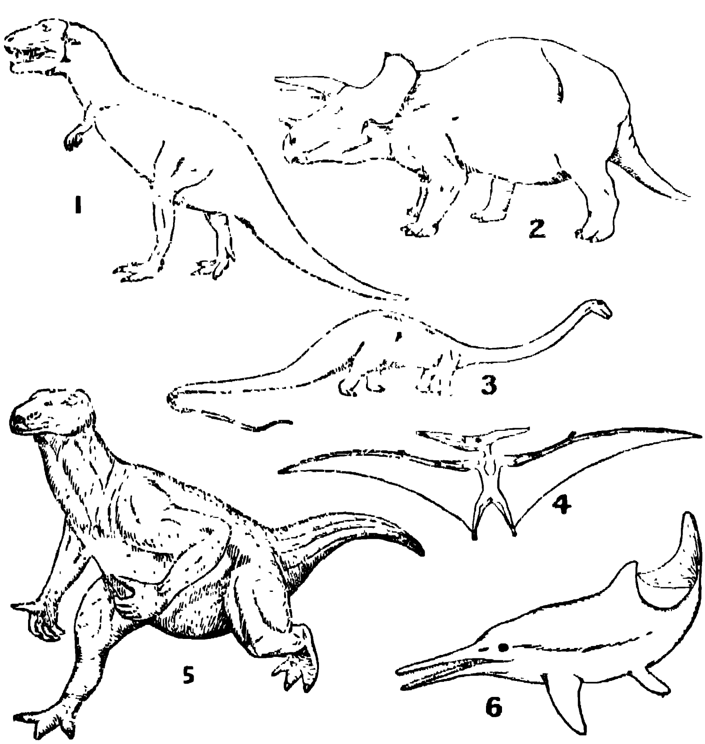
develop from eggs, with leathery shells, usually laid in some warm spot. The young appear as miniature editions of the adult, and have to shift for themselves from the start. Some reptiles have become viviparous, the mother retaining her eggs until they hatch.

Development of Reptiles

During the Mesozoic era reptiles formed the dominant group of animals living on land. Some, however, were adapted to an aquatic life, others modified the fore-limbs into wings. By the beginning of the Cainozoic (or Cenozoic) era most of the reptilian orders were extinct.

Reptiles arose from the Amphibia during the Carboniferous era, by developing an amniotic egg which freed them from the necessity of breeding in water ; in structure the earliest reptiles were very like the Amphibia. With more active habits the limbs became more strongly developed, and modifications of the skull, connected with the action of the jaw muscles, appeared. As they met with no competition on dry land, and as there was by then plenty of food available on land, the reptiles expanded in the Mesozoic into a bewildering variety of forms, very difficult to classify. The class can be divided into six sub-classes, not of equal value, some of which may be artificial assemblies of forms not really closely related. No attempt will be made here to deal with all these sub-classes.

One very important division, however, is already apparent in the Permian era. Certain reptile orders, common in the Permian though not so well known from later rocks, were of a type which later give rise to the mammals, and had various characters—for instance, in the structure of the skull and jaws—which were mammal-like and different from those of any of the other reptile groups, living or extinct. In the mammal-like reptiles the skull articulated with the vertebral column by a double condyle ; there was a gradual development of a hard palate separating the nasal passages from the mouth cavity ; one bone of the lower jaw, the dentary, became larger while the other jawbones became smaller, and the character of the jaw articulation changed, the bones which originally formed the jaw articulation becoming incorporated into the ear. Some of the Permian mammal-like reptiles were large, but the Mesozoic forms which actually gave rise to the mammals were small and therefore are rare as fossils. Mammals already existed in the Jurassic, but did not become dominant land animals until most of the reptiles of the Mesozoic had died out.



SOME EXTINCT REPTILES. 1, Tyrannosaurus, length about 50 feet 2, Horned dinosaur, Triceratops, length 20-25 feet. 3, Diplodocus, about 90 feet. 4, Pteranodon, wing-spread 25 ft. 5, Iguanodon, about 34 feet. 6, Ichthyosaur, about 30 ft.

Dinosaurs

It is not possible in a limited space to deal with the other sub-classes of reptiles systematically. Radiating in the Triassic, they reached their peak during the Jurassic and Cretaceous, remaining the dominant form of life on land for well over a hundred million years. The cause of the eventual extinction of all but a few lines is not clear ; none of the largest sub-class, the Archosauria, survived the Cretaceous, with the exception of the crocodiles. At the end of the Cretaceous there was a period of mountain-building, and the climate became colder ; vegetation must have been affected by these factors, and probably the reptiles lost their accustomed habitats and food, and were too specialised to adapt to the new conditions. Some groups, however, had already declined before the end of the Cretaceous ; there is no need to imagine a catastrophic

extinction of the ruling reptiles, as long periods of time would be involved.

Those orders of reptiles popularly grouped as dinosaurs, the "terrible reptiles," included a great variety of forms, some quite small, others surpassing all existing land animals in size. Some were vegetarian feeders walking on all fours, such as *Diplodocus*, which reached the immense length of 90 feet. These very large herbivores probably lived in swamps. Others were actively predaceous carnivores with very formidable teeth, like *Tyrannosaurus*, which reared its 50 foot body aloft on its hind legs. Other forms also developed powerful hind limbs of disproportionate length, on which they walked or hopped. *Iguanodon* is an example; it was a herbivorous type. *Triceratops* was a late dinosaur, a terrestrial herbivore about 20 feet long ; its neck was protected by a plate of bone extending from the back of the head, and the forehead and snout bore horns.

Ichthyosaurs

Among the extinct marine reptiles the Ichthyosauria or "fish-lizards" were large animals with fish-like bodies, paddle-shaped limbs, and long jaws furnished with abundant strong conical teeth. The ichthyosaurs appear to have been viviparous, a useful adaptation in a reptile probably unable to come on land. In their structure they show resemblances to the marine mammals, the dolphins and porpoises, though they are quite unrelated ; such resemblances are said to be due to *convergent evolution*, different animals evolving, independently, similar structures to answer similar demands of the particular environment

Pterodactyls

The pterodactyls succeeded in flying, the first vertebrates to do so. The known forms appear to have lived on sea-coasts and to have caught fish. The skin was drawn out into a flying membrane much like that of the bat. But while in the bat all four fingers are greatly elongated into slender supports for this membrane, only the little finger was thus modified in the pterodactyl, and formed a stout jointed rod to strengthen the outer edge of the wing. *Pteranodon*, which lived in Cretaceous times, had a wing spread of 25 feet, and was the largest flying reptile.

The pterodactyls, like the dinosaurs and crocodiles, were archosaurs, and from this order also arose the birds. The earliest known birds in the Jurassic, were, except for the presence of feathers, like the small dinosaurs.

Recent members of the Reptilia can be arranged in five orders, each with well-defined characters, as follows: (1) Chelonia, including tortoises and turtles ; (2) Rhyncocephalia, now represented only by the tuatara, *Sphenodon*, which lives on small islands in the Bay of Plenty, New Zealand ; (3) Squamata, the lizards and snakes ; (4) Crocodilia, the only surviving archosaurs.

Crocodiles and Alligators

Crocodiles and alligators inhabit rivers and estuaries of tropical regions. The snout is armed with powerful interlocking teeth ; the valvular nostrils are set on the top of the snout, so that the animal can move with most of its body submerged and at the same time breathe readily ; a bony palate separates the air passages from the mouth, as in mammals. The prey is held under water until drowned, if too large to be swallowed at once. The body is not only protected by horny scales, of which those along the upper side of the tail form a saw-edged ridge, but is also defended by bony plates or scutes in the skin. The stomach is not unlike that of a bird, part of it being converted into a muscular gizzard, the crushing action of which is enhanced by stones and other hard objects, which are swallowed from time to time. The heart is four-chambered, as in mammals and birds, not three-chambered, as in other reptiles and amphibians. Alligators, which are confined to the New World, are distinguished from crocodiles by the sharp canine teeth of the lower jaw. These fit into depressions at the upper jaw edges. The garials are fish-eating species.

Tortoises and Turtles

In tortoises and turtles (Chelonia) the teeth are replaced by a strong horny covering to the jaws, making up a kind of rounded beak, which is hooked in the carnivorous members of the order. The most characteristic feature of tortoises and turtles is the remarkable defensive armour. The body is sheltered in a strong case consisting of an upper shield or *carapace*, which is more or less firmly united at its edged with a lower shield or *plastron*, making up a sort of box, into which the head, tail, and limbs can be partially retracted. The outer layer of the case is composed of horny plates, which in some marine species form the source of "tortoise-shell." Beneath these are bones, some of which are derived from backbone and ribs.

The extremities of land tortoises are stumpy and clawed. In marsh and fresh-water tortoises the limbs are more flattened and serve as paddles, a modification which is carried to its extreme in the marine members of the order, turtles, where the limbs are powerful flippers.

Lizards

A familiar example of this sub-order of the Squamata is the sand lizard, *Lacerta agilis*, native to Britain, often seen in summer basking in the sun on banks or scrubby slopes. While

the animal remains motionless, it easily escapes observation, because its mottled brown skin harmonises well with the surroundings and affords a good example of protective coloration. The small creature is capable of exceedingly rapid movement, darting quickly upon the insects, worms, and other small animals which constitute its food. The body is clothed with horny scales derived from the upper layer (epidermis) of the skin, which is dry and devoid of glands. The scales are different from those of fishes, since these are derived from the deeper layers of the skin, or dermis. On the terminal digits the scales form horny claws. The long tail is cylindrical, thick near the trunk, tapering towards its hinder extremity—almost twice as long as head and trunk together.

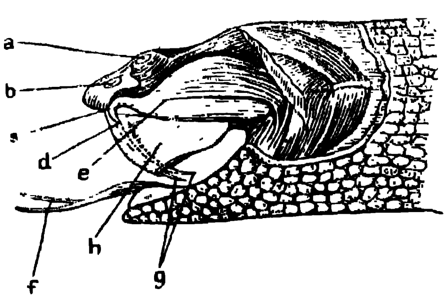
In some instances the tail has an important function in protecting the lizard from an untimely end, for when seized suddenly it readily snaps across and affords time for escape. This curious procedure is made possible by weak places in the backbone.

Ribs and Tongues

Reptiles have ribs ; the foremost ones, belonging to the neck region, are short and, like those of the hinder part of the trunk, have free extremities. The ribs of the thorax are attached to the breastbone lying on the lower side of the body, a characteristic that is not evident in lower vertebrates.

In tetrapods the vestiges of the gill arches, which have not become the *stapes* of the ear form the basis of support for the tongue muscles, the hyoid skeleton. In lizards the tongue is forked at the tip. It is used as a sense organ, of touch and of smell, being protruded from the mouth and then inserted into a special part of the olfactory organ which opens into the roof of the mouth.

Some tropical lizards, such as the iguanas of America, attain a great size. The iguana, which is esteemed as food, may be as much as six feet in length. Geckos have curious pads under their toes which enable these animals to scramble up smooth vertical surfaces with alacrity. The chameleon has hands and feet resembling sugar-tongs with hooked prongs, the digits being bound together into two groups, forming grasping organs. This reptile is also notable for the distance to which it can shoot out its adhesive club-shaped tongue to catch insects. It is proverbial for the way in which it can rapidly change its colour to suit various backgrounds, so as to harmonise with them. This variable coloration is protective, making the chameleon invisible to its foes.



POISON APPARATUS OF RATTLESNAKE.
a, eye ; b, nasal opening ; c, poison duct entering the posion fang at d ; e, poison sac ; f, tongue ; g, opening of poison duct ; h, pouch of mucous membrane enclosing poison fangs.

Snakes

Snakes are closely related to the lizards ; the shape of the body has become extremely narrow, elongated and cylindrical, and well suited to a life spent in wriggling through undergrowth. The limbs have almost entirely disappeared; the hinder ones of pythons are represented by a pair of insignificant stumps, each of which terminates in a claw. In the absence of limbs the junction between trunk and tail regions is indicated solely by the opening of the cloaca. The loss of limbs may originally have been a modification for burrowing.

Snakes are essentially carnivorous and are able to swallow animals much larger than themselves. This is rendered possible by the distensible nature of the body, due in part to the absence of breast bones and shoulder bones. Further, the two bones of the lower jaw are not firmly united at their forward extremities, but are connected by an elastic ligament which stretches easily. To preclude the possibility of choking during swallowing, the top of the windpipe is drawn out into a long cone, which temporarily protrudes from the side of the mouth.

On the lower surface of the snake's body are a number of prominent horny shields arranged in a double series, and to the ends of these the ribs are attached. By means of appropriate muscles the ribs can be moved, so that the shields are carried forwards one after another, resulting in a rapid gliding mode of progression. One might almost say that the snake walks on the tips of its ribs. Accompanying this movement are undulations of the body from side to side, producing a writhing motion. Such movements are facilitated by an extremely flexible vertebral column, the vertebrae of which are provided with additional locking joints that guard against dislocation.

Teeth and Poison Glands

Many snakes are non-poisonous and these possess numerous conical, backwardly projecting teeth on the jaw edges and on the roof of the mouth, which—though of no use for chewing—hold the prey firmly and prevent its

escape. The common grass-snake, *Tropidonotus*, is a good example of such forms. It is particularly fond of the neighbourhood of streams and is an expert swimmer. Its favourite food consists of frogs and fishes. Other examples of non-poisonous snakes are the boas and pythons of tropical America, which crush comparatively large animals into shapeless masses, and then, having lubricated them with abundant saliva, swallow them.

Venomous snakes have glands opening into the mouth and secreting a poisonous fluid, which is introduced into the blood of the bitten victim. Vipers are the most specialised snakes, and in these creatures the teeth are reduced to a pair of hollow fangs in front of the upper jaw. On each side of the head is a large poison gland connected with the cavity of the fang by a narrow canal. When the mouth is closed, the fangs are folded back against the roof of the mouth with their tips directed backwards; but when the snake opens its mouth and "strikes," the fangs are moved forwards and erected so that their sharp tips can be brought into action. Poison enters the wound made by the fang by a small opening near the tip of this structure. England's only poisonous snake, the adder, is common on sandy moorlands and in other dry or stony situations. It rarely exceeds two feet in length, and can be distinguished from the grass snake by its broad triangular head and short tail. The colour is yellowish brown, and a broad dark zigzag stripe is seen along the upper side of the body.

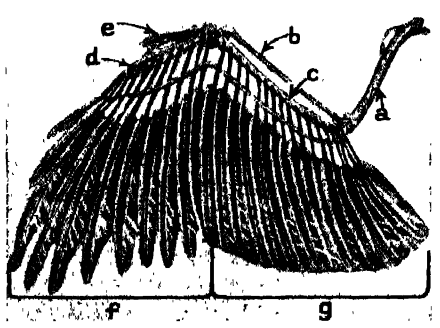
LESSON 26

The Structure of Birds

Feathers are distinctive of birds, so a bird can be defined as a feathered animal. Birds are also warm-blooded, egg-laying, bipedal, with not more than four toes, and with forelimbs transformed into wings.

The question of how feathers came to be evolved is still shrouded in mystery. There is some resemblance between the modes of development of feathers and reptilian scales; both arise as outgrowths of the outer layer of the skin (epidermis) which become horny, and both lie partly buried in the deeper layers (dermis) which form a nutritive core. The scales of reptiles are never moulted completely as are feathers, and though the scales on the feet and elongated ankle bones of birds closely resemble reptilian scales, zoologists do not know of any stage between scales and feathers.

Fossil remains of early birds are extremely rare, only two specimens of *Archaeopteryx* being known; these had perfect feathers. It is possible that some of the archosaurs from which birds arose may have been warm blooded, and that the earliest feathers had an insulating function, just as they do to-day, the flight feathers being acquired later in the course of evolution. There is, unfortunately, no direct evidence as yet.



WING OF A BIRD. a, humeros; b, radius, c, ulna; d, hand; e, bastard wing; f, primary quills; g, secondary quills. The ligament, below c and d, across the base of the quill feathers keeps these in position.

The surface brought to bear against the air in flight is formed of the quill feathers of the wings, which together form an area of large extent in proportion to the bulk of the bird. These feathers present the necessary combination of lightness and strength, together with the requisite flexibility. Examining one of them closely, it is seen that the hollow quill at the base is continued as an axis of an expanded vane, the numerous side branches (barbs) of which adhere closely together. The reason for this becomes apparent on looking at some barbs under the microscope, for these will be seen to bear still smaller branches (barbules) beset with interlocking hooks. The loose texture of the plumes of the ostrich—not a flying but a running bird—is due to the lack of such hooks.

Support for the Wing Quills

While in a bat the fingers are much elongated to support the flying membrane, the opposite is true of a bird, where firm support is required for the wing quills. The bone corresponding to that of our upper arm (humerus) is short and strong, and is succeeded by two bones of the modified forearm (radius and ulna), of which one (the ulna) bears the so-called secondary quills. There is much fusion in the bones of the hand, which has only three digits. The first of these (or thumb) bears a tuft of feathers known

as the bastard wing, and the remaining two support the primary quills. The quill feathers are kept in orientation to each other by an elastic ligament running unbrokenly along the entire wing and passing across their bases.

Mechanics of Bird Flight

The motive power for the effective downstroke of the wings is supplied by very large muscles (pectorals) which make up the flesh of the breast. Here also are the smaller muscles that raise the wings, the tendons of which pass over a sort of pulley formed by bones of the shoulder girdle, to be attached to the upper edge of the humerus. The wing is pulled down with its concave under-surface sloping upwards and backwards, and part of the force expended goes to support the bird in the air, the other part being spent in propelling it forwards.

The wing is cambered when extended, acting as an aerofoil ; the flow of air past the wing is such that the pressure above is reduced, thus providing lift. The shape of wings varies according to the type of flight. Fast flyers such as swifts have wings with a small total area but a long span ; they are very manoeuvrable at high speed, but stall easily if the speed drops. Birds with flapping flight have short wings with a small area, and special arrangements for twisting the feathers on the up-stroke to allow the air to slip between them. Birds which soar or hover, such as hawks or vultures, have wings with a large area, suitable for slow flight. All birds can glide to some extent ; this faculty is especially developed in sea-birds, the most extreme example being the albatross. They make use of the variable air currents above the sea to provide lift. Large birds which soar above land, eagles and vultures for instance, make use of thermal currents: columns of warm, rising air, in which they ascend in slow spirals. The radiating quills attached to the stumpy tail are steering feathers ; they appear to serve also as a brake in flight, or on landing.

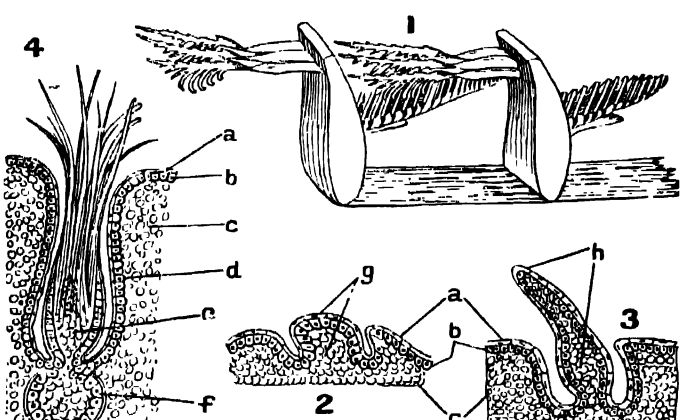
Becoming Airborne

Large birds may experience difficulty in taking off, and must take a long run in order to work up sufficient momentum ; the take-off of a swan from water is a familiar example. Herons and eagles nesting on trees and cliffs will be able to take advantage not only of their height from the ground but also of rising air currents in the vicinity. Small birds can become adequately airborne simply by jumping from the ground.

Skeletal Features

Teeth have been discarded ; in their place a horny beak has been developed. The head has become very mobile : it can be turned through half a circle, chiefly owing to an elongation of the neck by multiplication of its vertebrae. This also permits a bird to reach to the ground, to preen its feathers, and to perform other necessary manipulations.

The breastbone or sternum has been enormously enlarged for attachment of the great pectoral muscles which move with the wings. The ribs of the thorax comprise two parts : an upper vertebral part connected with the vertebral column, and a lower sternal part associated with the sternum, the two sets together forming a complete framework of the thorax. The vertebral and sternal ribs slope backwards from their point of union, making an angle behind. When this angle is reduced - as it is by contraction of muscles connecting the rib halves—the distance between the sternum and the vertebral column is increased; that is, the cavity of the thorax is enlarged. Thus air is drawn into the lungs, which are firmly attached to the thorax wall.



STRUCTURE AND DEVELOPMENT OF A FEATHER. 1, Small portion of feather with pieces of two barbs, each having to the left three distal barbules, and to the right a number of proximal barbules, many belonging to adjacent barbs. 2, Early feather-papilla in its follicle. 3, Feather-germ. 4, Down-feather in its follicle : a, stratum corneum ; b, stratum Malpighii ; c, dermis ; d, follicle of down feather ; e, calamus of down-feather ; f, follicle of permanent feather ; g, feather papilla ; h, feather-germ.

Bones of the Leg

Owing to the conversion of the fore limbs into wings, the hind limbs of the bird are set far forward, so that the body is more nicely poised ; and for their support there are very long hip bones, united to a region of the backbone composed of a number of joints fused together (*sacrum*). Certain bones of the legs have been lengthened. Beginning at the

upper extremity, there is a rather short thigh bone (*femur*), followed by a long shin bone, an elongated shank bone, and four toes. The bird walks on its toes, and the ankle joint is therefore raised off the ground, and corresponds in position to the junction of shin and shank bones. No small irregular ankle bones (*tarsals*) are seen because, in the interests of firmness, half of those in the typical pentadactyl limb have united with the lower end of the shin bone (the *tibia* being here a *tibiotarsus*), while half have fused with the bones of the sole of the foot (*metatarsals*) to form the single shank bone (*tarso-metatarsus*).

Bills and Feet

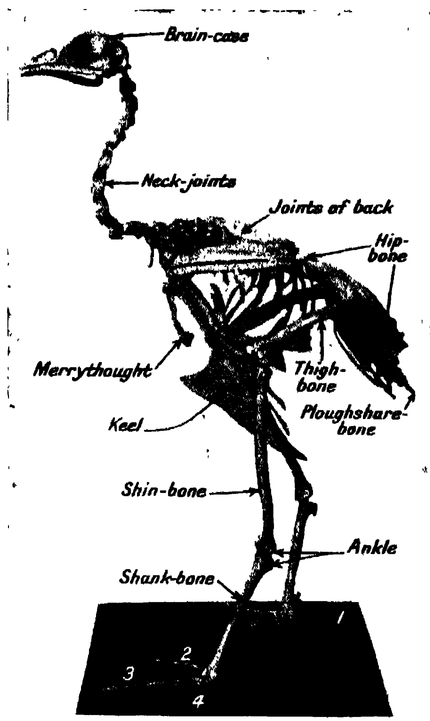
Birds are varied feeders, so it is not surprising to find numerous modifications of feet and bill as well as of the digestive apparatus. The crow has a generalised bill—strong, not too pointed, and suited to a variety of purposes. This type of bill is shortened, sharpened, and curved in birds of prey ; flattened and broadened in mud feeders like the duck ; drawn out into a slender bill for capturing insects, in warblers and wrens, or into a delicate probe for seeking nectar, in humming-birds; and modified in a thousand and one ways for various feeding purposes. Feet mostly have to do with walking, running, perching, or swimming, but may be concerned with the capture of food, as in eagles and ospreys. The eagle's foot, like that of most birds, has three toes directed forward and armed with powerful claws, and one (the first) directed backward. Owls can bend the last toe backward beside the first. A parrot holds food to the mouth with its foot, which thus serves as a hand.

Perching Mechanism

Of all the structural modifications of the bird's body there is space in this Course to mention only the most interesting ones. Of these, one connected with the muscular system is important ; it concerns certain muscles of the leg which go to form a curious perching mechanism. In the foot of a fowl a pull upon a single tendon serves to bend all the toes. This tendon passes over the ankle joint. In the roosting bird the weight of the body, falling on the legs, tends to bend the shin bone (*tibiotarsus*) more completely on the shank bone (*tarso-metatarsus*), which stretches the tendon. This results in the flexure of the toes, which thus grip the perch firmly. The grip is maintained while the bird is asleep by the weight of the body.

Breathing and Song

The lungs of a bird are small, indistensible bags curiously prolonged into a number of cavities, called air-sacs. The windpipe, or trachea, which is supported in birds by bony (not cartilaginous) rings, divides on entering the



SKELETON OF A FOWL showing the principal bones and joints of birds. The figures indicate the toes.

thorax into two smaller tubes or bronchi. These divide into still smaller branches in a peculiar manner. A main branch passes through the lung and leads into an air sac in the abdomen, but gives off a branch on each side to similar sacs in the hinder part of the thorax. The remaining part of each bronchus forms a number of branches leading into air sacs in the front part of the thorax, in the neck, and between the forks of the merrythought or fused collar bones. The oxygen demands of such active animals as birds are high, and the air sacs aid efficient respiration. At inspiration, air passes down the main bronchus into the posterior air sacs ; at expiration, this air passes through the lungs and into the anterior air sacs, whence it can be expelled to the exterior. The device ensures that no " dead air " is left in the lung, and, as it were, makes double use of every breath. Some of the air sacs also communicate with air spaces in the bones which ensure lightness of the skeleton.

The voice of birds is not produced by the larynx or voice box, as in mammals, but by a structure peculiar to birds, called the *syrinx*. This lies at the point at which the trachea divides into bronchi, and is an enlargement of this junction, across the cavity of which accessory vocal cords, a pair of membranes, are

stretched. These structures vibrate when air passes rapidly over them, and in vibrating give rise to musical sounds The pitch of the sound can be altered by muscles pulling on the membranes, which are very well developed in singing birds.

Digestive Apparatus

As an example of the internal digestive arrangements of birds which swallow hard food, one might conveniently take the domestic pigeon. Here the gullet is swollen into a large crop, the inflation of which gives the pouter its characteristic appearance. It is used for the temporary storage of food, and is not digestive. It leads into an oval stomach or *proventriculus*, from the lining of which digestive juices are poured out. A hinder division of this organ has thick muscular walls and a tough brown lining. This is a mechanical stomach or gizzard which, containing stones and other hard objects swallowed periodically by the bird, churns up and triturates (or masticates) food particles and completely compensates for the absence of teeth in the jaws. If the pigeon is fed constantly on flesh instead of grain, the brown lining is shed, and the gizzard becomes glandular and ceases its grinding work. Herring gulls may change the nature of the stomach lining twice in the course of a year, feeding on fish in winter, on grain in summer. Some flesh-eating birds, however, have as well-developed a gizzard as the pigeon, e.g. crows and kingfishers.

The final part of the alimentary canal (a long, coiled intestine) opens into a cloaca. In birds this chamber is partially divided into three smaller chambers, which lie in line one behind another. Into the first one (*coprodaeum*) opens the terminal part of the intestine, into the second (*urodaeum*) the urinary and reproductive ducts lead; the last (*proctodaeum*) opens externally by an aperture through which sperms and eggs, urine and faecal matter must pass to the exterior.

Circulatory System

Warm-bloodedness is one of the distinctive features of bird biology. The temperature of the blood of birds is about 40° to 44° C., which is warmer than that of mammals. This high body heat can be taken as an indication of the rapid rates of oxidation, that is to say, combustion, proceeding in the body. Birds have a heart with the ventricle divided into two chambers. There is a single systematic arch, on the right side, not on the left as in mammals.

Because of the very large size of the wing muscles (pectorals), the blood vessels carrying blood to them are correspondingly large. The main veins of the body are a single inferior and paired superior venae cavae. The renal portal system has disappeared, so that blood from the hinder parts of the body passes directly into the inferior vena cava, but may travel by an alternative vein (the coccygeo-mesenteric) into the hepatic portal vein, and thence to the heart by way of the liver. This alternative vein is peculiar to birds. There is a peculiarity of the blood corpuscles of birds. These bodies are biconvex and both larger and more numerous than in other vertebrates, a feature associated with the increased activity of life in birds.

LESSON 27

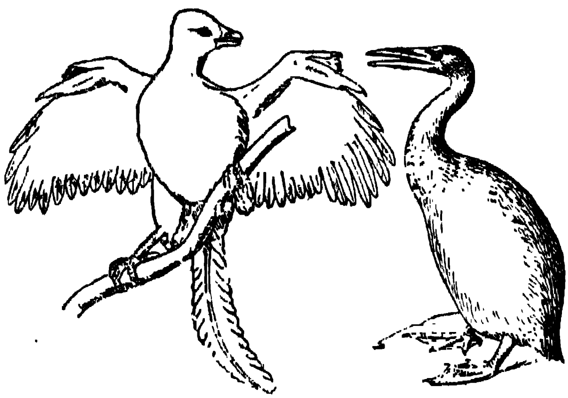
The Classification of Birds

THE class Aves is divided into two sub-classes containing: (1) Old Birds (Archaeornithes) and (2) New Birds (Neornithes), of which the former includes only one genus, the extinct form known only by its fossil (*Archaeopteryx lithographica*). The fossilised remains of this remarkable creature, which was about the size of a rook, and birdlike in its ways, were found in the Jurassic lithographic slates of Bavaria, at Solenhofen. Though having feathered wings, this animal showed certain reptilian characters, and it can be regarded as a link between reptiles and birds.

The Neornithes contain three divisions: (1) Odontognathae, or toothed birds; (2) Palaeognathae, or running birds; and (3) Neognathae, or flying birds. In the course of animal evolution there seems to have been a frequent bifurcation into more active and more sluggish types, and there is no doubt that a cleavage of this sort occurred very early in the evolution of birds.

Toothed Birds

The Odontognathae include interesting fossil birds. It has already been mentioned that *Archaeopteryx* flourished during Jurassic times. The first primitive birds appeared in the next succeeding geological period, the Cretaceous, in the form of the Odontognathae, which appear to be an offset of the main avian line of descent. The jaws held numerous teeth implanted in grooves. *Hesperornis* was about three feet in length, a highly developed diving bird which was flightless. *Ichthyornis*, found in the same beds as *Hesperornis*, was more slightly built, about one foot tall, and a powerful flyer. It had a large head with a long pointed beak, and numerous teeth in sockets in the jaws, and pointing backwards.



PRIMITIVE BIRDS. Left, restoration of the extinct Archaeopteryx, the oldest known bird; length approximately 19 inches. Right, Hesperornis, a diving bird of the Cretaceous period; length nearly 4 ft.

The Palaeognathae date from Miocene times, if not from the Eocene, and achieved world-wide distribution. They are flightless birds, usually large, and differ from all other members of their class in several features. The breast-bone or sternum, which in flying birds has a prominent keel or *carina* for attachment of the pectoral muscles, is keelless, or the keel is vestigial. The barbs of the feathers are disconnected, owing to the fact that the barbules lack hooks. The wings and wing muscles are greatly reduced in size. The body is uniformly draped with plumage except in naked patches on the extremities and on the head and neck. There is no voice box or syrinx.

Existing Palaeognathae are represented by *Struthio*, the African ostrich; *Rhea*, the South American ostrich; *Casuarius*, The Austro-Malayan cassowary; *Dromaeus*, the Australian emu; *Apteryx*, the New Zealand kiwi, and the *Tinamers* of S. America. The giant *Aepyornis* of Madagascar has long since gone, and the giant moa (*Dinornis*) of New Zealand has also disappeared.

The great majority of modern birds are included in the Neognathae, which usually possess a strongly keeled sternum and hooked barbules. The more important orders are considered here.

Divers and Grebes

The divers and grebes (Colymbiformes) occupy a rather isolated position in classification. They have downy feathers in young and adult stages alike, the wings are generally short and narrow, the strong, sharp beak is flattened from side to side, the legs are set far back, and the toes are webbed (fringed with flaps of skin in grebes). These birds are well adapted to the pursuit of fish. Two grebes commonly haunt British inland waters. *Podiceps cristatus* is the great crested grebe, *P. fluviatilis* is the little grebe or dabchick. The adults have a swift, direct flight with head and feet fully extended, but on leaving lake or river they are able to rise from the surface of water only with difficulty. The diver order (Gaviiformes) has two common species, the great northern and the red-throated divers. Divers are marine except at breeding time, when they ascend rivers and build their nests on moors. They are not gregarious unless forced to fly inland by gales or stormy weather.

Penguins

This order of marine birds (Sphenisciformes) is found in the seas of the Antarctic. They are flightless birds and their rudimentary quill-less wings are clothed with fine scale-like feathers. When the birds are submerged during swimming operations, the wings are used as paddles. They progress on land by a curious waddling gait, are tame and fearless ashore, and, when irritated, show great pugnacity. They breed on land, often without nests. The emperor penguin never comes to land; it breeds on the ice, carrying the egg on its feet. The eggs of penguins are preyed upon by other birds, and the young are fed for a long period by the adults.

Petrels, Albatrosses, Fulmars

These are oceanic birds (Procellariiformes) with webbed feet (the great toe is missing) and remarkable powers of flight. The strong, somewhat hooked, beak is well adapted for fish-eating, and the horny sheath or bill is composed of several pieces, in both upper and lower jaws. The wings are generally long, narrow, and pointed. Many of the largest flying birds are included in this order, as also a few of the smallest, some petrels being scarcely larger than finches. Most species inhabit desolate tracts of ocean and islands in the southern hemisphere, but a few are common around the coasts of Britain.

Gannets, pelicans, cormorants, and frigate birds, of the order Pelicainformes, are mostly marine, with good powers of flight; all four toes are included in the web. The order Ciconiiformes embraces long-legged water or marsh birds, usually fish-eating, such as the herons and bitterns, storks, ibises, and flamingoes. In spite of their long legs and necks they are strong flyers.

Swans, Ducks, Geese

The species of the large and cosmopolitan order Anseriformes are web-footed, aquatic birds, mostly with flattened bills covered with soft skin and edged above and below with horny plates. They are almost entirely vegetarian

feeders. One extensive family includes swans, ducks, and geese. The British wild duck, *Anas boschas*, which is the form from which domestic species have arisen, is a typical member of this family. Diving members of the family include the eider duck, a British winter visitor; the teal and the widgeon are non-divers and common objects of sport. Of geese indigenous to Britain the grey lag is perhaps best known; the domestic goose is probably descended from it. Swans are included in this order, the white species being common throughout Europe and extending to Asia and Africa. The black swan of Australia and the black-necked swan of South America are remarkable for their colour.

Vultures, Hawks, Eagles

The predaceous character of members of the order Falconiformes is clearly indicated by the strong, hooked beak, and the powerful talons, admirably adapted for seizing prey. Members of this order occur the world over. One family includes vultures of the condor type, birds of immense size with a hooked but not sharp bill and with feet not suited to grasping. The head and neck of these birds may be bare, or covered with a short stubble of down, and the naked skin is sometimes brightly coloured. They can soar to great heights and have remarkably keen sight. The members of the falcon family, which includes hawks, eagles, kites, buzzards, and ospreys, have the characters of the typical falconiform bird and are distinguished from vultures by the covering of feathers on head and neck. Another family includes the secretary bird of Africa.

Game Birds

These birds, the Galliformes, are ground birds, with strong, blunt-clawed feet adapted for scratching up the ground in search of food. The family Phasianidae alone calls for comment, including as it does turkeys, fowl, grouse, and guinea-fowl. Guinea-fowl have been derived from a West African species; turkeys from a North American form; the red jungle fowl of southern Asia (*Gallus bankiva*) is ancestral to domesticated fowls. The peacock was originally native to the same region.

Cranes and Bustards

These are long-legged birds (Gruiformes) living for the most part in marshes. They lack a crop. Members of the rail, coot, and water-hen family have flattened bodies, which facilitate movement through the dense undergrowth constituting their home. The crane family includes forms bearing superficial resemblance to herons, being long-legged and having slender necks. Bustards have a thick neck and a flat head.

Plovers, Snipe, Gulls, Pigeons

The birds belonging to the order Charadriiformes may be marine or terrestrial. The plover family are waders that fly well, but are not swimmers like the gull and skua family. Gulls are widely distributed sea-birds with a staple diet of fish and other marine animals, though they migrate inland for feeding and breeding. Britain's commonest forms are the common gull, the herring gull, and the black-headed gull. Other relatives are the terns or sea-swallows, recognized by their pointed wings and tails. The chief British representatives of the auks are the razor-bill, the guillemot, and the puffin or sea-parrot. Pigeons belong to the order Columbiformes; a member was the dodo of Mauritius, a large flightless form, now extinct.

Parrots and Cuckoos

In the members of these orders the first and fourth toes are directed backwards, the last toe sometimes being reversible. The cuckoo belongs to the order Cuculiformes, characterized by a gently curving bill, deeply cleft and long pointed wings. A sharply marked group is that including the parrot, order Psittaciformes, with its strongly curved and hinged bill.

Owls, Swifts, Woodpeckers

The flying birds with short legs fall into several orders. To the Coraciiformes belong the beautifully coloured rollers and kingfishers, as well as bee-eaters, hoopoes, and hornbills. In several other orders are nocturnal creatures with forwardly directed eyes, such as owls (Strigiformes); wide-mouthed nightjars (Caprimulgiformes); swifts and humming-birds (Micropodiformes), the latter the smallest of all birds which flit from flower to flower; and woodpeckers (Piciformes). These last are powerfully built birds with an enormously elongated tongue, flat and horny claws, and a firm tail that is used as a prop during climbing. The toucan and wryneck are members of this last order.

Perching Birds

The order Passeriformes is a vast assemblage of some 5,500 species, including half the total number of known birds. The feet of such birds are modified for grasping and perching, and the vocal organs are well developed. Classification into families is especially difficult, and is accomplished with respect to the arrangement of the syrinx muscles. The order includes such birds as thrushes, robins, wrens, hedge-sparrows, nightingales, blackbirds, and whitethroats, as well as swallows and martins, crows and their beautiful relatives called birds of paradise: also magpies and jays, ravens, starlings, finches, and numerous other well-known birds.

LESSON 28

Mammals and their Classification

The Mammalia are vertebrates which breathe air, have warm blood, and are covered with epidermal out-growths in the form of hairs. There are also other distinctive features. The skull has two condyles connecting it with the first vertebra, in distinction to the single condyle of the reptiles and birds. Plates of gristle (epiphyses) are at the ends of the vertebrae and long bones of the limbs of the growing animal ; when growth ceases, these become bony. The lower jaw consists of a single bone on each side, and is joined to the skull by a bone called the squamosal, the quadrate bone found in birds and reptiles in an intermediate position having no relation to jaw suspension in mammals, but joining one of the middle ear bones.

Mammalian Characteristics

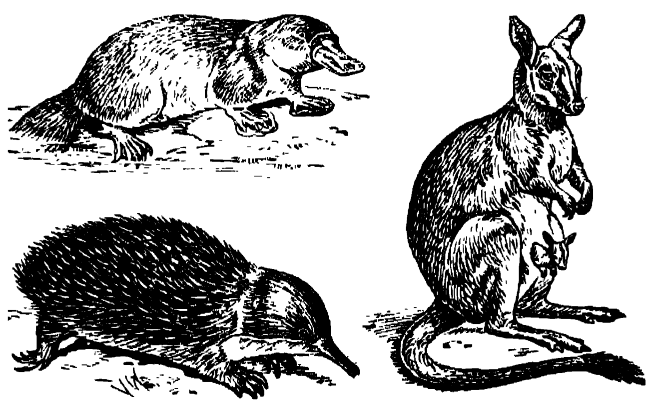
Most mammals have two sets of teeth, forming the milk and permanent teeth respectively. The teeth are implanted in sockets and are of different shapes, being distinguished, for this reason, as incisors, or cutting teeth ; canine, or tearing teeth ; and premolars and molars, or grinding teeth. A muscular partition divides the body cavity into two parts, the thorax (which contains the heart and lungs) in front, the abdomen (which contains the digestive and reproductive organs) behind. The heart consists of two auricles and two ventricles, one of each of these cavities on either side being completely separate from its fellow of the opposite one. There is a single aortic arch, but this corresponds to the left arch of reptiles not the right as in birds. The blood corpuscles are discoidal in form and lack nuclei.

The mammals are remarkable for the great development of those parts of the brain concerned with learning and intelligence. They are for the most part individually adaptable, compared with birds or reptiles, and this has probably been an important factor in their evolution. Man himself is the foremost example of this, and owes his supremacy to a fine brain and an upright posture, together with stereoscopic vision, and hands.

Most mammals are *viviparous*—that is, they bring their young into the world alive as miniatures of themselves. The unborn animal (foetus) obtains nourishment from the blood of its mother by means of a special organ (the placenta) which develops in the womb and becomes embedded in the womb wall. After birth the young animal receives nourishment from the secretion of milk or mammary glands. Exceptions to the first of these rules are found in the most primitive group of mammals, the Monotremata. These include *Echidna*, the spiny ant-eater, and *Ornithorhynchus*, the duck-billed platypus, both of which occur in Australia. The Monotremata are much more primitive in structure than any other existing mammals and have several striking points of resemblance to reptiles.

Metatheria and Eutheria

The two other main groups of the Mammalia are the Metatheria and the Eutheria. The Metatheria are pouched mammals. The Eutheria are mammals such as are common in Britain. Excepting the American opossums, the members of the Metatheria are natives of the Australian regions, where, in the absence of competing types, they have acquired an amazing diversity of character, due to adaptation to most varied habits. The marsupial wolf (*Thylacinus*) is a flesh-eater ; the banded marsupial ant-eaters (*Myrmecobius*) are insectivores ; the pouched mole (*Notoryctes*) is a burrowing form ; the kangaroo (*Macropus*) is herbivorous, with a greatly developed leaping progression ; the wombat (*Phascolomys*) burrows after roots ; the phalangers (*Phalanger*) are arboreal. Most of the types of mammal in the northern hemisphere are paralleled in the southern hemisphere by marsupials. The



SOME PRIMITIVE MAMMALS. Upper left, the duck-bill or duck-billed platypus (Ornithorhynchus), an Australian mammal with several reptilian resemblances. Though oviparous, it feeds its young on exuded milk. Lower left, a spiny ant-eater (Echidna), another mammal of the Monotremata group. Right, a rock wallaby, a typical marsupial.

young marsupial is born in a very immature condition, and crawls into a sheltering pouch formed by a skin fold on the underside of the mother's body.

Mammalian Orders

The most general characteristics of the various orders of existing Eutheria are as follows. The diagnostic characters of these orders are usually skeletal, to allow of inclusion of fossil forms.

Flying Lemurs

The Dermoptera (flying lemurs or colugos) are herbivorous climbing animals, with an extensive flying membrane. Of the two species, one occurs over an area extending from Burma to Borneo ; the second is native to the Philippines.

Insect-eaters

Insectivora (insect-eaters) form a large and ancient order of small creatures occurring in nearly all parts of the world. They are specially adapted to feed on insects and other small animals. Hedgehog, mole, and shrew are British species. They show many primitive mammalian features. Sometimes placed in a separate order, the Menotyphla, are the tree-shrews and elephant-shrews, which have larger brains than the other insectivores and may be related to the Primates. The tree-shrews are arboreal insect-eaters. The elephant-shrews are small long-snouted animals with elongated metatarsals ; the muzzle is often so much prolonged as to resemble in shape an elephant's trunk.

Bats

The Chiroptera (bats) are closely related to the Insectivora, but differ from them in having wings. (The bats of the East Indies are fruit-eaters.)

Men and Monkeys

Primates (men and monkeys). All the members of this order are possessed of relatively large brains. This affects the general form of the skull, and one result is the forwardly directed eyes. With the exception of man and the gorilla, these mammals are adapted to a climbing life in trees, and the feet are efficient grasping organs. The types most closely approaching man in structure are the man-like apes (Anthropoidea). Of these, the gorilla and the chimpanzee are native to tropical Africa, the orangutan belongs to Sumatra and Borneo, the gibbon to south-east Asia.

Gnawing Mammals

The Rodentia (gnawing mammals) is a large order of widely distributed animals that are mostly small and adapted for vegetarian life, though some are omnivorous. They possess four chisel-edged incisor teeth, growing continuously throughout the animal's life and kept permanently sharp. Familiar British types are the squirrel, rat, mouse, and vole. Rabbits and hares are in a separate order, the Lagomorpha ; they have four incisor teeth in the upper jaw instead of two as in the rodents.

Flesh-eating Mammals

In the Carnivora (flesh-eating mammals) a great variety of predaceous forms are included. The Felidae (cat family) embraces species best adapted to carnivorous life. To this family belong the lion and tiger, as well as civets and other cat-like creatures. The Canidae (dog-family) includes dogs, foxes, wolves, and jackals, which are less specialised than members of the previous family. Another family is the Mustelidae, represented by badgers and small bloodthirsty forms like weasels and the fish-eating otters. Another family is the Ursidae or bear family, the members of which are omnivorous (with the exception of the polar bear) and less specialised than other flesh-eaters. The family of aquatic fish-eaters known as the Pinnipedia includes the walrus, sea-lion, and seal, all of which are well adapted to marine life, as the form of the body and of the flipper-like extremities well testify.

Even-toed Ungulates

The Artiodactyla (even-toed ungulates) and the following order include most of the large herbivorous hoofed mammals, as well as a few omnivorous ones. The hoofed extremities are well adapted to swift progression on land. Zoologists distinguish between two ungulate types, odd-toed and even-toed respectively, terms that refer to the number of digits on the hind foot. The omnivorous swine and the plant-eating hippopotamus do not chew the cud, and in this respect differ from ruminants like deer, oxen, goats, sheep, giraffes, etc.

Odd-toed Ungulates

The Perissodactyla (odd-toed ungulates) include the pig-like tapirs of south-east Asia and tropical America, which have four toes on the fore foot, three on the hind foot ; the rhinoceroses of Africa and south Asia have three toes on each foot. The horse and its allies have but a single toe, which is greatly enlarged, on each foot.

Conies

The Hyracoidea (conies) order includes small animals, often confounded with rabbits, which inhabit African and Syrian deserts. The fore foot has four toes, the hind foot only three, and these are provided with small hoofs, with the exception of the inner toe of the hind limb, which is clawed. The upper incisors are somewhat like those of the rabbit, but the back teeth are very different.

Elephants

The Proboscidea (elephants) are huge plant-eaters, native to Africa and south Asia, with teeth which are much specialised ; the drawing

out of the snout into a prehensile trunk is a notable peculiarity.

Sea-cows

The Sirenia (sea-cows) are an order of plant-eating marine animals represented only by the manatee and the dugong, which inhabit the shores and estuaries of the South Atlantic and the Indian ocean respectively. The tail is flattened horizontally, the fore limbs have become modified into flippers, the hind limbs have disappeared.

Whales and Porpoises

The Cetacea (whales and porpoises) are even more completely adapted to aquatic life than the Sirenia. The whalebone whale and its allies are toothless, but porpoise and sperm-whale have numerous pointed teeth.

Ant-bear

Tubulidentata are the aardvark or ant-bear order. This animal, which is indigenous to South Africa, is about 5 feet in length; its large body is almost hairless, with short legs, pointed ears, and a tapering snout. It has a long tongue covered with slime, and with this it catches ants. It burrows out a home from which it emerges only at night.

Pangolin

Pholidota (pangolin or scaly ant-eater): a lizard-like creature, varying from 1 to 3 feet in length according to species, the pangolin is found only in Africa and India. It is covered with scales, and is also protected by its odour.

Toothless Mammals

Edentata (toothless mammals): the chief living representatives of this order occur in South America and to a small extent in the Old World. But not all are toothless, as are the ant-eaters, which belong here. The leaf-eating arboreal sloths and the burrowing mail-protected armadillos have teeth, but these lack the enamel covering characteristic of mammals.

Mammalian Development

The mammals were already in existence during the Jurassic period, though very little is known of such early forms; the animals were small and most of the remains in the Mesozoic consist of teeth only. The expansion of the class did not take place until the early Cenozoic, after the ruling reptiles of the Mesozoic had disappeared. The mammals, warm-blooded and more intelligent, were presumably able to adapt to the change in climatic conditions which was fatal to most of the reptiles.

Having no direct terrestrial competitors of other classes (for the birds occupy different ecological niches), the mammals radiated rapidly during the early Cenozoic, most of the orders of to-day being established by the end of the Eocene. Man first appeared in the Pleistocene; crude flints said to be of human manufacture are found in Lower Pleistocene deposits, and evidence of undoubted human culture (the early Palaeolithic) comes from the Middle Pleistocene. Bones of our own species, *Homo sapiens*, appear in Europe in the Late Pleistocene, not more than 20,000 years ago.

LESSON 29

Adaptations of Mammalian Teeth

In order to survive, animals must be adapted to their particular mode of life; such adaptations may show themselves in any of the structures of the body. An obviously important variant in habit is the diet—at the extreme, whether this is herbivorous or carnivorous, with sub-divisions in each category. The physiological and morphological nature of the digestive system will be correlated with the diet, and the most obvious structures so affected are the teeth. A brief survey follows of the variation of the form of the teeth in different mammals, as an example of the kind of variation that may affect several other organ systems.

Composition of a Tooth

A tooth consists of a bone-like substance, *dentine*, surrounding a *pulp-cavity*, and covered over by *enamel* and *cement*. Nerves and blood vessels run into the pulp-cavity. Enamel is developed from the epidermis. The remainder of the tooth is formed by the deeper layer of the skin, the dermis.

During the development of an embryo the mouth ectoderm lying above the jaws sinks below the general surface as a long band, the *dental lamina*, which follows the curve of the jaws. From this band minute tooth rudiments are produced as buds in two groups, one giving rise to the milk teeth, the other to the permanent teeth appearing by replacement later. The early tooth rudiment is a hollow cup formed of a double layer of cells, the *enamel organ*, which embraces a finger-like projection of the dermis or *dental papilla*.

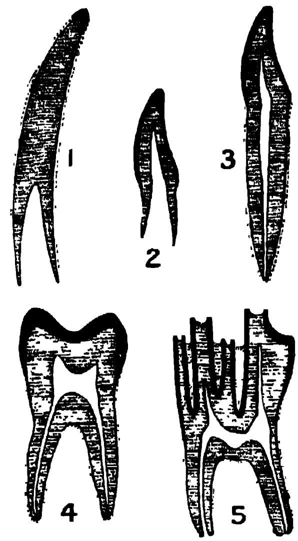
The cells of the inner layer of the enamel organ secrete enamel in the form of a thin continuous sheet, while the most superficial cells of the dental papilla or *odontoblasts* form successive layers of dentine (a system of delicate parallel tubes containing organic fibrils and impregnated with lime salts), of which the bulk of the tooth is composed. The inner cells of the dental papilla form tooth pulp, a loose reticulum of cells and fibrils. The tissue surrounding the tooth rudiment becomes vascular

and encloses the entire structure in a *dental sac*, from which blood vessels pass into the developing pulp. As the rudiment enlarges, it projects from and eventually breaks through the epithelium of the mouth, when the outer layer of the enamel-organ (or enamel-membrane) is ruptured. The teeth of most mammals develop distinct roots, each with a minute aperture communicating with the pulp-cavity, embedded in the bone of the jaw.

Varieties of Teeth

The teeth of the primitive mammals were beset with sharp tubercles. Teeth of a somewhat similar type are still to be found among the small animals which make up the order of insect-eaters (Insectivora). A good type of this group, which is common in the Old World, is the European hedgehog (*Erinaceus*). In accordance with the nature of its food, mostly consisting of worms, small insects, and snails, the teeth of the hedgehog are sharply pointed, those at the back having their crowns provided with small cutting projections. Such teeth are eminently suitable for dealing with not only such small creatures as mentioned, but also snakes, frogs, and even mice, none of which is despised as an article of food. The name hedgehog, by the way, is suggested by the shape of the snout, which is something like that of a pig, and is used in much the same way for grubbing in the ground.

Herbivorous mammals need teeth able to grind up tough vegetation, and usually have the tubercles of the molars elongated and running into one another in various ways to form a series of ridges. Complex grinders are seen in the horse. The elaborately ridged crowns of these teeth are composed of three kinds of material, enamel, dentine, and cement, which vary in degree of hardness and maintain the rough surface by unequal wearing. Canine teeth are virtually absent, though often feebly represented in the stallion, and the incisors are provided with deep pits, which get filled up with food and show that practical guide to age, the black "mark"



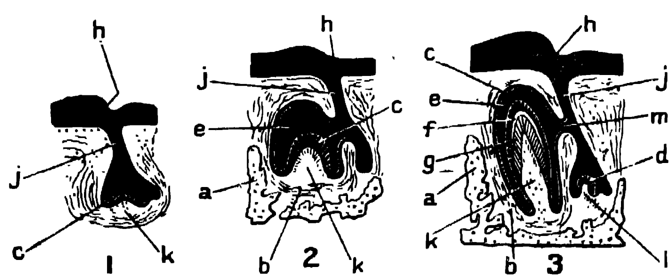
FORMS OF TEETH. Diagrammatic sections. 1. Incisor or tusk of elephant with pulp-cavity persistently open at base. 2. Human incisor during development, with root imperfectly formed and pulp-cavity widely open. 3. Completely formed human incisor. 4. Human molar with broad crown and two roots. 5. Molar of the ox, with enamel covering of crown deeply folded and depressions filled with cement; the surface is worn by use. Enamel shown black, pulp white, dentine by horizontal shading, and cement by dots.

on the crown. Among the Artiodactyls, sheep and cows have teeth with characteristic crescentic ridges, with the interstices filled up with cement as in horses; the omnivorous pigs have teeth with several separate tubercles instead of ridges.

Teeth for Gnawing

The large order of gnawing mammals (Rodentia) is represented in Britain by the squirrel, rat, and mouse. There are two chisel-edged incisors above and below, and a number of prismatic grinding teeth with transversely ridged crowns farther back. A wide space, or diastema, due to the lack of canines, separates the two kinds of teeth. All the teeth grow continuously throughout life. The incisors remain sharp because they are thickly coated in front with relatively hard enamel, but consist mostly of dentine or ivory (which is not so hard) behind. Hence they wear unequally and maintain a sharp edge. As the teeth are constantly growing, constant gnawing is necessary to keep them worn down. A rodent which is so unfortunate as to lose an incisor is handicapped by the unchecked growth of the opposing tooth, which attains an inordinate length and may even cause the death of its possessor.

Equally interesting are whales and porpoises (Cetacea); they have derived from terrestrial ancestors by a line of descent which is still somewhat doubtful. Some members of the order have numerous sharp simple teeth, well suited for seizing and holding



MAMMAL TEETH. Three stages in development: a, bone; b, dental sac; c, enamel-membrane; d, enamel-membrane of permanent tooth; e, enamel-pulp; f, layer of enamel; g, dentine; h, dental groove; j, dental lamina; k, dental papilla; l, dental papilla of permanent tooth; m, neck connecting milk tooth with the dental lamina.

slippery fishes and cuttles. The common porpoise is one of the most familiar forms ; the huge sperm whale or cachalot is an example of a toothed cetacean on a large scale. Whalebone whales have no functional teeth, for though in very early life teeth are to be found embedded in the gums they never penetrate. Instead there are numerous pairs of horny plates (baleen), frayed out at the edges and hanging down from the roof of the mouth. So-called whalebone was formerly derived from them. The whales of this group feed upon small animals which float in enormous numbers at or near the surface of the sea, making up what is called " plankton." Moving along at some speed, the whale takes in large quantities of sea-water, which is strained through the baleen, leaving behind in the mouth the swarms of minute creatures (largely copepods) it contains. Danger of choking during this process of feeding is obviated by the cone-like top of the windpipe, which fits into the back of the nasal passages in such a way that water cannot find its way into the lungs.

Teeth for Tearing Flesh

The Carnivora have teeth adapted to tearing flesh. The cat family (Felidae) includes beasts of prey such as the lion, tiger, leopard, and cheetah of the Old World, and the puma and jaguar of the New. Examination of a lion's skull serves to show some of the specialisations that exist in connexion with the carnivorous habit. The jaws are enormously strong, and the lower one is raised by powerful muscles inserted in prominent ridges seen on the skull. The canine teeth are sharp tusks used for seizing and holding prey, while the crowns of the back teeth are cutting blades of great efficiency. In carnivores of this family, as also of the dog family (Canidae), there is one tooth on each side of each jaw which is enlarged and modified for tearing. This so-called carnassial tooth is the last premolar in the upper jaw and the first molar in the lower. Bears and seals do not have well-developed carnassial teeth.

Teeth for Grinding

Bears (Ursidae), with the exception of the Polar bear, are omnivorous ; while the canines form prominent tusks, the back teeth are blunt-crowned grinders suitable for dealing with a miscellaneous diet. Seals are aquatic carnivores, of Pinnipedia, to which order the walrus and the sea-lion also belong, distinguished by the possession of a thick coat of fat (blubber) beneath the skin. The walrus has paddle-like limbs and only a scanty covering of hair. The upper canines form large tusks used for grubbing up shellfish as food ; the grinders have blunt crowns well suited to crushing the bodies of these food animals. Sea-lions and seals have closely set fur, the former being sometimes known as eared seals on account of their minute external ears. Both types have narrow, sharply pointed back teeth suitable for holding fish.

Complete loss of teeth is usually associated with an ant-eating habit. Fruit-eaters have low-crowned rather simple teeth, as do most primates, the fruit-eating bats, and the kinkajou. The possession of such teeth of superficially similar appearance does not necessarily indicate any relationship.

LESSON 30

Animal Reproduction

All living creatures have arisen from pre-existing living things, and most animals are the products of that remarkable cell, the fertilized ovum, which results from the union of male and female reproductive cells or gametes. Some animals, it is true, are formed as buds from the parent's body, and some eggs develop without having recourse to the process of fertilization. But these are comparatively rare exceptions.

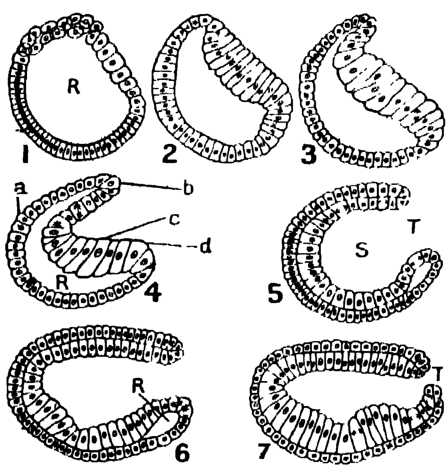
Early Development

The egg of *Amphioxus* is an appropriate subject for the study of early development, because it contains little yolk material, which, in the eggs of fishes, amphibians, reptiles, and birds, modifies early development, its abundance providing obstacles and mechanical difficulties. This egg, after fertilization, divides into two, four, eight, sixteen, thirty-two, sixty-four and larger numbers of cells, which arrange themselves in the form of a hollow ball or *blastula* (*see* illus. p. 2094). This division of the egg into cells is called *segmentation*. In *Amphioxus* the egg divides up completely, for which reason segmentation is said to be total or *holoblastic*. In the yolky eggs of fishes and birds, abundant yolk prevents the formation of a simple blastula; instead, a flat plate of cells is formed on the upper surface of the yolk. The generative protoplasm does not divide up completely, and segmentation is said to be partial or *meroblastic*.

One side of the blastula of *Amphioxus*, the future posterior side, becomes flattened. Here the cells are relatively large, and at one point they grow inwards towards the cells of the future dorsal surface, forming a lip which gradually extends completely round the flattened region.

The tucking-in process is known as *invagination*, and the lip of the intucked region is the lip of an opening called the *blastopore*. In the region of the blastopore lip cells are multiplying rapidly and are growing over the posterior end of the embryo, a process (epiboly) which converts the simple blastula into a two-layered hemispherical cup. The cavity of the cup, which leads to the exterior by the blastopore, is the rudiment of the gut or *archenteron*, for the original cavity of the blastula (the *blastocoel*) has been obliterated between the two layers. Epiboly continues, resulting in an elongation of the embryo and a narrowing of the blastopore. The embryo at this stage is called a *gastrula*, its two layers of cells being ectoderm (outer), from which the nervous system, sense organs and epidermis will be formed, and endoderm (inner), which later forms the digestive canal and its derivatives like the liver and lungs. *Gastrulation*, therefore, results in the separation of two of the three germinal layers which characterise the triploblastic animal.

Subsequent changes result in the separation from the endoderm of the third germinal layer (mesoderm) and the notochord. The latter is seen in the elongated gastrula as a strip of cells above the archenteron in the middle line, the mesoderm appearing as a wider strip on each side. Each mesoderm band develops a longitudinal groove open widely into the archenteron. As the groove deepens, a pair of small pouches are cut off from it in front, their cavities being completely separated from the archenteron.



GASTRULATION IN AMPHIOXUS. Diagrams showing flattening (1 2) and infolding (invagination) (3 -5) of the blastula, the blastocoel becoming obliterated and the archenteron established; (6–7) elongation of the gastrula and completion of gastrulation. a, ectoderm; b, dorsal lip of blastopore; c, endoderm; d, ventral lip of blastopore; R, blastocoel or segmentation cavity; S, archenteron; T, blastoporal opening. See text beginning on p. 2093.

The walls of the pouches form the first pair of somites; behind these, numerous other pairs are developed later. With the formation of the somites the three germ layers are initiated.

Germ Formation

The details of germ layer formation vary in different members of the Vertebrata, but the general principles of early development are the same. The presence of yolk, or the development of the embryo within the body of the mother, results in modifications of the process of segmentation and gastrulation, often by a short-circuiting process whereby certain stages are omitted. But the development of the embryonic structure from the three germinal layers is essentially the same in all vertebrates. From the ectoderm arise the epidermis (with its derivatives, scales, feathers, and hairs), the entire nervous system and the sense organs, the lens of the eye, the membrane lining, the mouth and nose, the enamel of the teeth, and the lower part of the digestive canal. From endoderm are derived the lining of the digestive canal (and of the larynx, trachea, and lungs), the liver, pancreas, thyroid, and thymus. The mesoderm supplies the raw materials from which are developed the connective tissues which bind the bodily parts together, the bones, muscles, blood vessels and heart (as also the blood), the teeth (excepting their enamel layer), the kidneys and their ducts, the reproductive organs, fat and bone marrow, and the membranes covering the heart, lungs, and digestive viscera and also lining the coelom.

At one time much stress was laid on the germ-layer theory, concerning the embryonic origin of the various types of tissue of the body. It is now known that the distinction between the various layers is not absolute, for certain embryonic structures do not fit easily into these categories, yet may be the precursors of important structures. The tissues of the germ-layer theory, however, are still very convenient to use in a descriptive sense.

Development of Brain, Eye, Ear

Ectoderm gives rise to the nervous and sensory structures of the body. On one side of the elongated vertebrate embryo rather tall cells form a flat plate, the *neural* plate, the edges of which rise up as folds that meet in the middle line to form a hollow *neural tube*, the forerunner of the spinal cord and the brain. The first indication of brain development is a dilatation of the front end of the neural tube into three large vesicles, divisions marking out future fore-, mid-, and hind-brain. Eye rudiments appear as outpushings of the sides of the fore-brain, which form a cup (the optic cup) on each side of the embryo, connected with the fore-brain by a narrow stalk. The lens of the eye,

however, forms as an ingrowth of superficial ectoderm towards the optic cup. As the ingrowth rounds itself off into a tiny vesicle, it becomes associated with the optic cup (that part of the rudimentary eye which forms the retinal layer and the overlying pigment layer), with which it forms the eye. The ears develop as paired ingrowths of the ectoderm at the level of the hind-brain, the olfactory organs as similar pits situated just above the mouth.

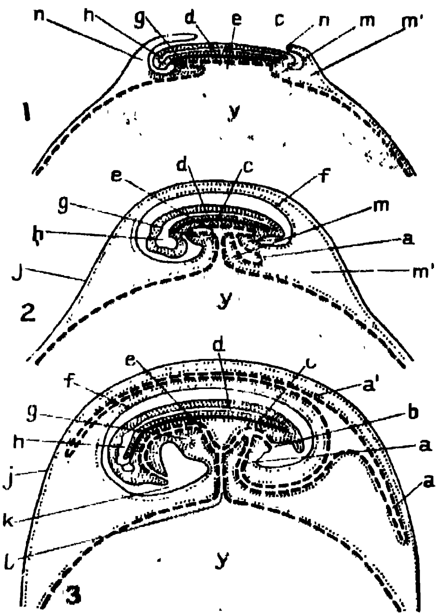
The Amnion Membrane

Reptiles, birds, and mammals are grouped together as Amniota, amphibians and fishes belonging to an alternative group of Chordata, the Anamnia. Amniota are so called on account of the protective fluid-filled membrane, the *amnion*, which envelops the developing embryo. This membrane is lacking in fishes and amphibians. The amnion arises in front of the head of the amniote embryo as an ectodermal fold, which grows backwards and soon covers the head. Upgrowths on each side of the embryo continue amnion growth until this fold completely covers the embryo. Amniotic fluid fills the space between the embryo and the inner layer of the amnion folds (or true amnion), to serve as a water-cushion or shock absorber and prevent undue buffeting of the embryo. This membrane is sometimes imperfectly removed during human birth, when the individual is "born with a caul," and deemed lucky.

Functions of the Allantois

Another important accessory to embryonic development in high vertebrates is the allantois. In the chick embryo this appears soon after amnion formation, as a down-growth of the floor of the hind part of the archenteron. It is thus endodermal, but has an outer covering of mesoderm. It grows out into the space between the true amnion and the fold outside this (the false amnion or chorion), which it soon completely fills. It thus comes to lie close beneath the porous egg shell and, being abundantly supplied with blood vessels, it is admirably fitted to function as a respiratory organ. This function of the allantois is of the greatest importance. Though the embryo has gill slits closely resembling those of the fish, these are not functional breathing organs, so that respiratory exchanges effected during embryonic development depend upon this function of the allantois. But this embryonic organ serves another function, that of accumulating waste products during embryonic life. When development is complete, the allantois is severed close to its connexion with the archenteron, the short stalk remaining to form the bladder of the new individual.

In mammal embryos the allantois plays yet another part. At a very early time during



FOETAL DEVELOPMENT IN BIRDS. 1, early stage in the formation of the amnion; 2, stage with completed amnion and commencing allantois; 3, later stage. The outer line is the ectoderm; the endoderm is represented by a broken, the mesoderm by a dotted line: a, a^1, allantois; b, anus; c, notachord; d, spinal cord; e, archenteron; f, amnion; g, heart; h, brain; j, membrane; k, mouth; l, umbilical duct; m, m^1, coelom; n, amniotic fold; y, the yolk-sac.

From Parke & Haswell, "Textbook of Zoology," Macmillan & Co.

pregnancy it establishes a connexion with the maternal tissues, and assists in the transport of nourishment from the mother to the embryo. In this way the placenta is formed at the point where the allantois and overlying embryonic membrane come into contact with the wall of the womb. Outgrowths from the embryonic tissues penetrate the wall of the womb; in many animals the maternal tissues are eroded until the embryonic tissues meet the maternal capillaries or even the mat.rnal blood, so that only the embryonic tissues separate the maternal and foetal blood streams. There is never actual mingling of the blood streams, for this would present considerable physiological problems. The interchange of nutrient and excretory substances is effected by diffusion across the tissues that are intervening.

Similarity between Embryos

In studying animal development one is somewhat astonished to find similar organs developed in much the same manner, and to find structures like gill clefts developed in the bird and mammal.

as well as in the fish. Another feature which impresses the student of comparative embryology is the great similarity between embryos of vertebrates like the dogfish, lizard, chick, and rabbit, or man during the early stages of development. During later development, however, such embryos tend to vary more and more, so that it becomes increasingly less difficult to distinguish between, say, the dogfish and chick embryos, or the chick and the human embryo. These facts make it possible for the expert to detect closer or more distant relationship, because, in general, the more closely allied two animals happen to be, the longer do the embryonic resemblances persist. One has to wait longer to detect embryonic structural differences between man and anthropoid apes than those between man and rabbit.

These facts are summarised in the so-called theory of recapitulation (the modern equivalent of Haeckel's biogenetic law), according to which the individual in its development to some extent repeats the history of the race to which it belongs. The embryos of the fowl and man develop along the same general lines because the ancestors of both evolved along similar lines before finally diverging. Anthropoid ape and human embryos resemble one another for a longer period during development because these types diverged later in the evolutionary history of the Craniata. The theory is not to be accepted without reservations, for, as has been shown, mechanical difficulties may modify development. Also, embryonic organs do not necessarily appear in the same chronological order in different craniate types, nor in the order of their phylogenetic appearance ; the order of their development may vary, for reasons that are not quite clear. But the theory fits the most generalised facts, and provides the embryologist with a means of collaborating with the palaeontologist in deciphering many complex problems.

LESSON 31

Growth of Animals

In attempting to gain a few impressions of what is implied by the term "growth," one cannot do better than select the most familiar living organism, man himself. Like other organisms, man arises as the product of a single living cell, the fertilized ovum. This seemingly simple unit of living matter contains all his growth potentialities, yet shows no trace of its inherent powers when viewed under the microscope. It is so small that if all the ova produced by a woman during her sexual life were laid in a row, this row would scarcely be one inch in length : the diameter of a human ovum is about one-fifth of a millimetre.

Rate of Growth

Whilst travelling towards the womb, the fertilized ovum divides up to form a hollow ball of cells or *blastocyst*, which embeds itself in the wall of the womb. Nutrient materials and oxygen are obtained from the mother, being first absorbed by the superficial cells of the blastocyst and later by the allantoic placenta. For about 40 weeks, the young human being, nourished by its mother, grows and develops, until the tiny ovum has become a baby weighing as a rule about seven pounds and measuring about 20 inches in length.

The ovum is a simple spherical cell, but the baby's body is a vast community of billions of cells of diverse types and belonging to tissues like bone, nerve, muscle, and blood. The cells resulting from division of the ovum have progressed along different lines to become fitted for a variety of tasks in the economy of the body after birth They have become *differentiated.* Growth, in the sense of size increase, has been accompanied by cell specialisation or differentiation. Moreover, cells showing similar characters have been aggregated into tissues, and tissues of various kinds have been amalgamated into organ systems with special functions to perform. This unfolding of organs implies something over and above differentiation into cell types, and it is given the specific name *morphogenesis.*

Regarding growth for the present as overall enlargement, which is a simplification of the facts, the rate of growth is not constant. Apart from the existence of diurnal variations in size, or fluctuations in growth rate over periods longer than this, there is a gradual falling off in growth rate as the individual becomes older.

During the last month before birth the foetus increases its weight by one per cent each day. If such a percentage rate of growth continued after birth we should have to get used to seeing one-year-old infants as large as adults. In the mammals and birds growth normally ceases on the attainment of adult size, though it is less certain that growth ceases altogether in the other vertebrates, particularly fish, which are thought to continue to grow, though more and more slowly, as long as they live. Many fish also show an annual fluctuation in growth rate caused by variations in the food supply, and probably also by the difference in sea-temperature in summer and winter, which must affect the general activity of a cold-blooded animal.

An inadequate food supply will obviously affect growth ; some animals without hard skeletons, such as flat-worms and sea-anemones,

will actually become smaller if starved, resorbing and using as food some of the substances of their own bodies. This does not happen in more highly organized animals. The arthropods are in a peculiar position as, having an exoskeleton, they cannot grow unless they moult the old cuticle and form a new one ; actual growth takes place quickly by the expansion of the new exoskeleton before it is hardened, after which the arthropod must wait till the next moult before it can again increase in size.

While a young animal is growing, its proportions are subject to great change. The head of a newly born infant takes up about one-quarter of the entire length of the body. The head is well developed because it has followed the growth of the brain, which has an early start and a high initial growth rate, and at birth attains one-fifth the weight of the adult brain. The fore part of the body grows most rapidly at the outset, the parts farther back growing progressively more slowly. Thus one speaks of an axial growth gradient with its high point in the region of the head.

The infant's body is relatively small at birth. It begins to grow later than the head and does not possess so high a growth rate. In order to attain normal adult proportions, therefore, it must grow more rapidly than the head after birth. The *sign* of the growth gradient must be reversed. The way in which the early growth advantage of the head is cancelled out after birth is readily seen by the fact that the body is four times the length of the head at birth, but eight times this length at maturity. The proportions of young animals are just as dissimilar from those of their parents. The calf and foal at birth have relatively huge heads and short, shallow bodies, poised on relatively long limbs.

All parts do not grow uniformly, nor do all organ systems. The skeleton grows at the same rate as the entire body and determines stature, though all parts of the skeleton do not grow at the same rate.

Growth of the bodily organs involves continuous competition between various parts. It can be likened to a long-distance race, in which some competitors start well but lack staying power, some pursue an even course, and some start badly but end with a flourish. Unlike the competitors in such a race, however, the parts of the body all finish simultaneously, so to speak.

Although the general growth rate ceases in an adult mammal, the growth of parts of the body such as skin, nails, and hair, continues throughout life, as also must the growth in the bone marrow to produce new blood corpuscles.

Some at least of the processes of growth are under the control of the endocrine system, the ductless glands of the body. But such factors cannot control growth before the glands themselves are differentiated. It is a primary characteristic of living matter that it can grow, that its substance is capable of self-replication. How this happens, and how the self-replication is controlled in such a manner that the organism will come to resemble its parents, is still a mystery. It is known, however, that special types of protein and other substances found in the nuclei of cells are of importance in this respect, and that the nucleus of the fertilized egg is the product of the fusion of nuclei derived from the two parents. When the fertilized egg cell divides, the substance of its nucleus is divided between the cells resulting from division, and something in the organization of those nuclei governs the ultimate fate of the cells. How this happens is not yet known, though something is known of the way in which certain parental characters may be expected to be distributed among the offspring.

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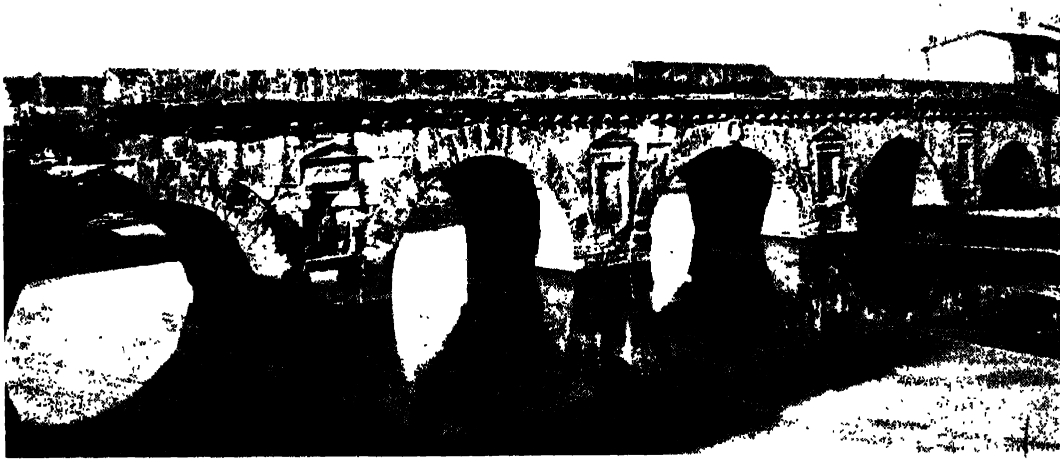
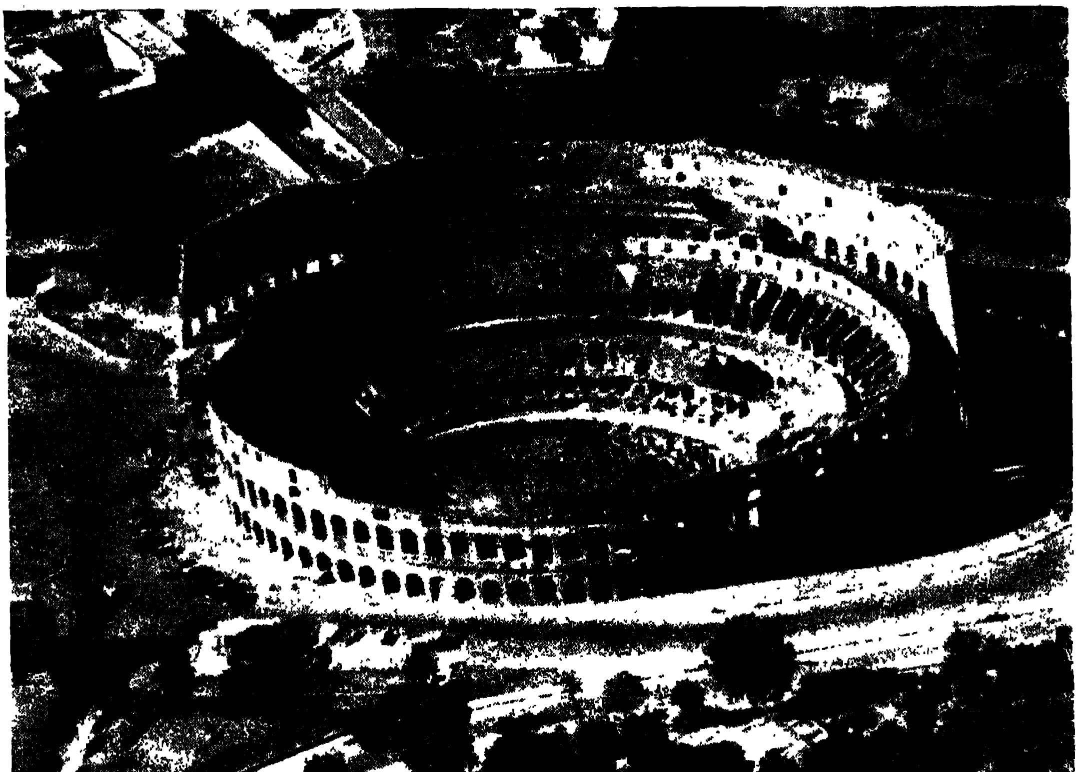


THE BRIDGE OF AUGUSTUS AT RIMINI (ancient Ariminum) which, built in A.D. 22, was so soundly constructed that it has withstood the traffic of nineteen centuries and is still in use. Its five arches are separated by massive piers containing in each spandrel an ornamental niche instead of the more usual flood arch.



ELOQUENT OF ROME'S CONSTRUCTIVE GENIUS. The Colosseum at Rome, begun by Vespasian in A.D. 72. Built round a huge elliptical arena 282 feet by 177 feet, the tiers of seats were arranged in four storeys each built on 80 open arcades. The whole building was 615 feet long, 512 feet wide, 160 feet high. Its ruinous condition is due to the ravages of medieval builders who wanted stone without the cost of quarrying.

SOCIAL HISTORY

History, wrote Edward Gibbon (1737–94), is " little more than the register of the crimes, follies and misfortunes of mankind." Most histories, not excluding his own " The Decline and Fall of the Roman Empire," would seem to justify his remark, since they are concerned almost entirely with political happenings, with wars and battles, laws and treaties, the fortunes of dynasties, the rise and fall of states. More and more it is coming to be recognized that these political histories leave out much of the very greatest interest and importance. The everyday life of the common people in all the centuries of the past does not afford such scope for dramatic description as the tales of blood and slaughter on which historians dwell ; but it is the work of the " great unknown " that has lifted humanity from its primitive beginnings to the immensely complex and varied life of the 20th century.

This Course tells something of this human adventure. The political background, some knowledge of which is not only desirable but essential, is given in the Courses on ANCIENT AND MEDIEVAL HISTORY *and* MODERN HISTORY *in Vol. 1, and* BRITISH HISTORY AND POLITICS *in Vol. 5.* SOCIAL ANTHROPOLOGY *in Vol. 2 and* ARCHAEOLOGY *in Vol. 3 may also be consulted with advantage.*

28 LESSONS

LESSON 1

Hunters and Artists of the Stone Age

HUMAN history begins with a question mark: it is not known when or where man first became man. Some anthropologists suggest that a hundred thousand, two hundred thousand, or half a million years may have elapsed since our ancestors "came down from the trees." Some declare that the race arose in central Asia, others that Africa was man's first home.

However that may be, as years go by the gaps in human knowledge grow less and less; and now, thanks mainly to the stone implements which early men left behind them, it is possible to trace the cultural development of Europe for fifty thousand years and more.

Those flakes and cores, scrapers and gravers, celts and borers, knives and arrow-heads, which fill so many glass cases in museums, tell what is to be learnt of the first Europeans. But the story is fragmentary and confused. About the oldest of the flints, the unshapely lumps or "eoliths" found in Red Crag at Ipswich in Suffolk, for instance, and in the gravels above Ightham in Kent, controversy still rages. Were they chipped by human effort, or by chance and the forces of nature?

Concerning the next most ancient finds there is more certainty. The big, clumsy-looking *bouchers* - so named because it was Boucher de Perthes (1788-1868), a customs officer at Abbeville, France, who first demonstrated their human workmanship—knuckle-dusters, hand-axes, or general tools-of-all-work, found in the drift gravels of the big rivers, tell something of the ways of life and mental development of mankind in the days before the last Ice Age, when the present river system had not taken shape, and when the climate was warm and dry. No bones of Chelleans or Acheuleans (so called because typical implements of their culture were found at the Amiens suburb of St. Acheul and at Chelles-sur-Marne) have come to light; only the flints bear witness to the existence of these people during many hundreds of centuries.

When the fourth Ice Age had the world in its grip, beetle-browed savages shambled in and out of caves. This was Neanderthal man (the Neanderthal cave near Düsseldorf, Germany, was where the first bones of the species were discovered, in 1857); the memory of him perhaps survives to-day in the ogre of nursery stories. Apparently he had the Continent to himself; the earlier folk had disappeared, perhaps killed by this fearsome creature, or perhaps driven south by the encroaching ice.

Neanderthalers or Mousterians

The Neanderthalers (or Mousterians, as they are often called, from the fact that typical flint implements were unearthed in the cave of Le Moustier, in the Dordogne, France) lived in a hard time. Forced to find shelter, they challenged the cave-bear and ejected him from his home. With flint arrows and spears they chased bison and deer; they caught mammoths and rhinoceroses in concealed traps. For thousands of years the Neanderthalers endured the winds and snows, the sand storms and drenching rains, of an inclement age. Then, about 12000 B.C., they disappeared from what is now Europe.

Their successors may have been the ancestors of some of the present European peoples. They were definitely *men*, and it is believed that they arrived by way of the land bridges which then linked Spain and Italy to Africa, and that as the ice retreated and the climate improved, they gradually spread across ever-widening grasslands. They too lived in caves; and in

A PAINTING OF TEN THOUSAND YEARS AGO. This painting on the wall of a cave at Cogul shows a group of women surrounding a solitary man. It may be a marriage scene or some other aspect of social organization among the Capsians in Spain.

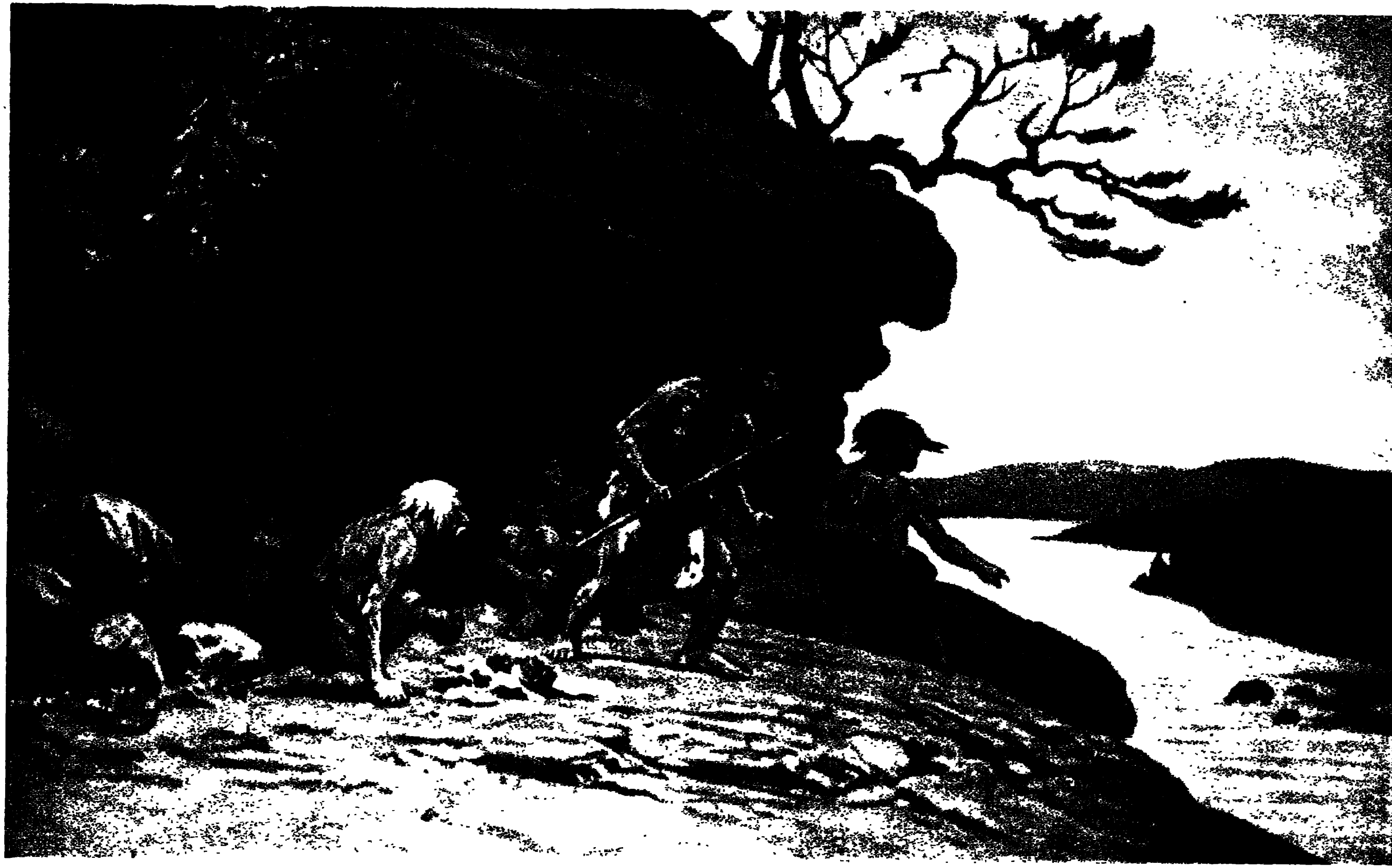
These bowmen from Morella la Vella are clearly engaged in mortal combat – first evidence for warfare between man and man.

On the left, a man collecting wild honey from a tree while the bees buzz round him. His bag is made probably of leather. Centre and right, male nudity contrasted with feminine trappings; these figures are engaged in ritual dancing.

Boar hunt, from the cave of Chaco del Agua Amarga in eastern Spain.

OCCUPATIONS IN THE DAILY LIFE OF THE CAPSIAN CAVE PAINTERS

From Obermaier, El Hombre Fósil (top and middle left), and Cabré, El Arte Rupestre (remainder)

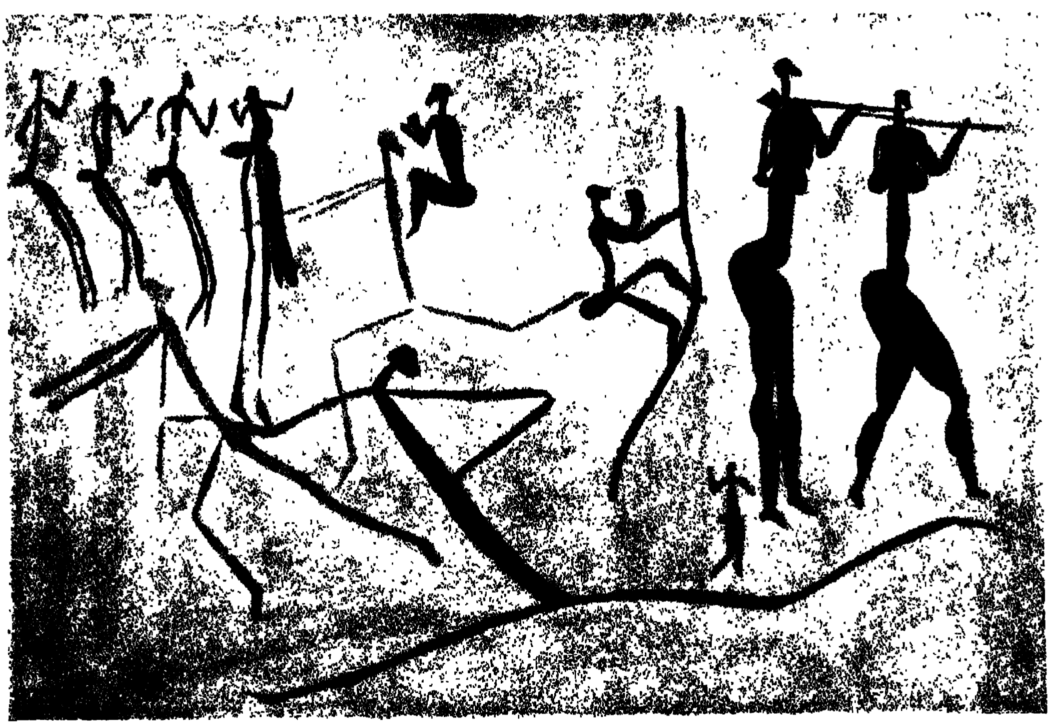


NEANDERTHAL CAVE DWELLERS SIGHT GAME BELOW THEIR HILLSIDE HOME

This illustration of a Neanderthal family at the mouth of their cave during the Fourth Glacial Period, presents a scene well authenticated by remains of the time. They are excited by the appearance of rhinoceros in the river below. They belonged to the Mousterian culture phase, when primitive man had made considerable progress in flint-chipping technique. Wooden tools, such as the fire-hardened spear held by the leader, were also in use. Neanderthal man disappeared in Europe probably about 12000 B.C.

Reconstruction by Charles R. Knight, American Museum of Natural History, New York

Recent art—though it does not seem to have been practised for a century or so—of the Bushmen of South Africa provides a parallel to the prehistoric Spanish paintings. Above, an eland hunt with spears and bows. In the picture below, the two unclothed women on the right are not unlike the Capsian women in general treatment, and the man climbing a tree is reminiscent of the collector of wild honey in the Plate facing page 2100



ART OF THE BUSHMEN OF SOUTH AFRICA

ART OF PREHISTORIC HUNTERS

Men of the Palaeolithic (Old Stone) Age painted these pictures of bison, deer and a wolf on the walls of the Magdalenian cave Font-de-Gaume near Les Eyzies, Dordogne in southern France

To face page 2101

France and Spain and elsewhere examination of cave floors has revealed a mass of débris of their feasts and burials; tools and ornaments display a sequence of development, classified by archaeologists according to the districts in France in which distinctive "finds" were made.

The earliest or Aurignacian stage (Aurignac cave, Haute Garonne) is marked by statuettes of fat and steatopygous (fat-buttocked) females, and by engravings on horn and ivory. Next came the Solutrean stage (Solutré, near Mâcon), distinguished by the beauty and quality of its stone implements; and then the Magdalenian (La Madeleine, near Dordogne), during which prehistoric art reached its zenith.

It is difficult to exaggerate the achievement of the Palaeolithic artists who lived some ten or twelve thousand years ago. In the farthest recesses of their caves they painted with red and yellow ochre on the smoother surfaces, by the dim light of lamps fed with animal oil, pictures of the beasts that roamed the country: the bison; the shaggy, long-tusked mammoth; the charging boar; the alert stag; the browsing horses; and the sleepy rhinoceros.

PREHISTORIC HUNTSMEN shooting arrows at deer were portrayed by a Capsian cave artist on a wall of rock in eastern Spain some ten thousand years ago. This painting is in a cave in the Barranco de Valltorta. **See also illus. in p. 2100.**

LESSON 2

Emergence of Modern Man

The first wave of "modern" men is supposed to have reached Europe, probably from Africa, about 12000 B.C. Wave after wave followed, and during the next five thousand years or so Palaeolithic culture spread northward across the continent.

Man was still a hunter; a gatherer of food, not a producer. He ate the grains and fruits collected by the womenfolk and children, but he had not yet learnt how to grow them. Animals were still foes or rivals; it is doubtful whether he had the companionship of a dog. He had no pottery, no metals; his tools and weapons were of stone, wood, and bone. In groups of two or three men with their women and children, our prehistoric ancestors roamed the grasslands in search of food, and at night huddled round the camp fire.

For thousands of years the Old Stone (Palaeolithic) Age ran a course unmarked by calendar and almost untouched by change, until it was overtaken by one of the great crises in human affairs. Further withdrawal of the ice sheet and the consequent slow spread of damp and gloomy forest across what had been the dry and sunny grassland wiped out the food supply of animals, the animals themselves, and the men who lived by hunting them. The civilization of the hunter-artists disappeared. The masterpieces of the caves were followed by the painted pebbles of the Azilian folk (so called because their characteristic stone implements and ornaments were found in abundance in a cave near Mas d'Azil, on the Garonne, France); and the cultural descendants of the Magdalenians waded among the shallows of the Baltic, clawing from the rocks the shellfish that composed their daily food. But while in western Europe culture degenerated and almost died, in south-western Asia or Egypt in the so-called "fertile crescent"—men were taking the first great stride in civilization: food gatherers were becoming food producers. The invention of agriculture (not later than 6000 B.C. and possibly very much earlier) was accompanied by improvements in the working of stone

IRRIGATION. This primitive method of watering dry fields is still used in Egypt. Leather buckets scoop up water from the Nile and lift it by stages to the top of the slope.

implements, the invention of the arts of pottery and weaving, the discovery of copper and the beginnings of working in metal, and the domestication of certain animals.

Of the beginnings of these supremely important processes very little is known. The men who first made two blades of wheat grow where they had seen but a single wild one, who wrapped damp clay about a basket framework, who tamed the jackal and penned the cattle of the steppes—these pioneers were the real founders of our world. They made history possible, and of them history knows nothing; mythology distributes their credit among gods and heroes, and explains very little.

In the Nile Valley

The consensus of opinion seems to be that civilization had its rise in the Nile basin rather than in Mesopotamia, the other most likely source of its origin. For countless ages the great river has flowed between its narrow walls; the almost unbroken regularity with which the valley's vegetation was renewed by the summer flood, loaded with rich earth washed from the Abyssinian mountains, may well have suggested to the primitive Egyptians that what the river did so well they too might do. Once agriculture and irrigation had begun, there would be a concentration and rapid growth of population; and the necessity of providing food for an ever-growing number of mouths must have stimulated further inventiveness.

According to Sir Flinders Petrie (1853–1942), the people of the Nile valley passed from the food-gathering into the food-producing stage at least ten thousand years B.C.; and although the date is still the subject of controversy, it is certain that long before the rise of the 1st Dynasty (3400–3200 B.C.) Egyptians were cultivating cereals, producing fine pottery and delicate work in flint, weaving fabrics and carving ivory, using boats on the river, and farming oxen, sheep and goats, and perhaps ostriches. They also painted their faces with malachite, the green ore of copper (apparently because green, the colour of the life-giving flood-water, was regarded as life-giving or lucky). From one end of the long valley to the other their culture was remarkably uniform.

Peasant Industries

In Mesopotamia, probably not long afterwards, the peasant began hoeing the fields with stone or wood implements. He hunted birds with bow-and-arrow and sling, and fished with nets and traps made of reeds. He planted and tended groves of date palms, and in his cultivated patch were many of the cereals and vegetables known to us wheat and barley, onions and mint, beans and lettuce, turnips, radishes, and cucumbers. His womenfolk for the most part stopped at home in the reed-built huts by the water's edge, looking after the children, preparing the food, grinding the corn, baking the pottery, and weaving the simple garments.

Black buffaloes stumbled through the mire, asses trotted along carrying heavy loads, the shepherd watched white and brown sheep in

A STILL OLDER METHOD of raising water in ancient Egypt is shown here. It was used before the invention of the system in the top photograph.

the clearings. Pedlars travelled from one village to another in boats made of bundles of reeds, carrying with them dyes and cloths, carpets and pottery—and in course of time a less-welcome voyager, the tax-gatherer, passed from island to island across the swamps, collecting the dues demanded by the priests of the near-by town for the service of their god.

Similar developments took place wherever climate and geography combined to facilitate the production of a regular food supply. As it was on the banks of Nile and Euphrates, so it must have been – probably somewhat later—on the banks of Ganges and Yangtse. All the river civilizations were based on water control ; if the floods failed, the people died.

As populations grew, irrigation became a necessity, and this gave rise to co-operation between villages and small city states. The supply remained more or less constant, but the area that must be watered to grow sufficient food was continually increased. Hence embankments had to be raised and maintained, fields measured, the water pumped up and diverted and fairly apportioned.

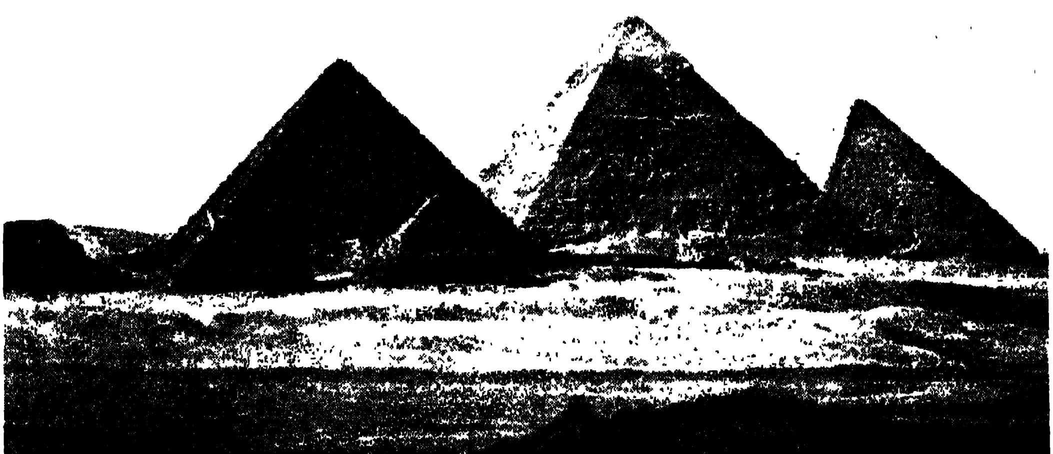
Civilization must have progressed fairly rapidly once the first (but hardest) steps had been taken, and it is obvious that these early river cultures were essentially peaceful. War appeared as an incursion from without, introduced by nomad hordes who envied the youthful civilizations their food and comfort. War, like luxury and leisure, may be regarded as one of the by-products of civilization.

LESSON 3

Life and Labour in Egypt and Mesopotamia

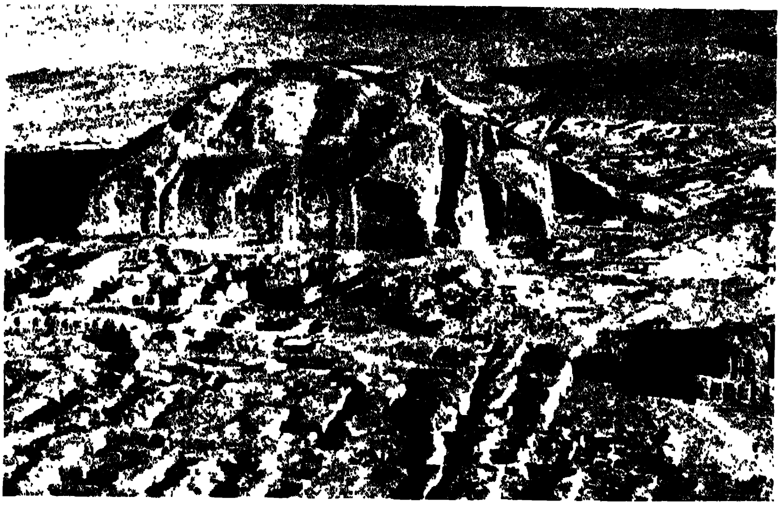
It is not known how long the civilization of pre-dynastic Egypt lasted before the country was unified under the first of its thirty-odd dynasties. Then, between 3400 and 3200 B.C., began the Old Kingdom, of which the principal monument consists of the pyramids.

Much has been written and conjectured about the pyramids, especially those at Gizeh. The theory that they were simply royal tombs designed to accord with Egyptian beliefs concerning immortality, induces sufficient respect for the scientific knowledge and skill and the power of organization involved. More elaborate theories have suggested (1) that pyramidal shape and mass were intended to defend the royal family, alive or embalmed, against the effects of gravity-induced disintegration of the moon, and (2) that the structure of the Great Pyramid embodied a system of prophecy of world events, to be interpreted through the observing of numerical correspondences of measurements of its chambers and corridors with periods of time. No matter what compulsion moved the builder-kings, the peasants were no



THE PYRAMIDS AT GIZEH. Three kings of the 4th dynasty built this famous group. In this view the Great Pyramid, that of Khufu (or Cheops), is on the left. Originally it stood 481 feet above the plateau, and it is estimated to contain 85 million cubic feet of stone.

Royal Air Force official, crown copyright



HOME OF THE MOON GOD. Air view of the huge mound at Ur, in the delta of the Euphrates, on which once stood the ziggurat or temple tower of Nannar, the moon god of Ur. As stone was very rare in Mesopotamia, the Sumerian architects used bricks of baked mud for even their most massive buildings. In the foreground are the crumbled remains of the great temple enclosure.

Royal Air Force official, crown copyright

doubt impressed to transport the masses of stone on floats and rollers from the limestone quarries across the Nile.

The Greek historian Herodotus (c. 484-424 B.C.) wrote that 100,000 men were thus annually employed during the three months' flood season—when, according to a modern Egyptian saying, the fellah goes to sleep. Remains of workmen's barracks suggest that about 4,000 craftsmen were continuously at work on the pyramids for perhaps 20 years. Especially during the 4th Dynasty (c. 2900 to 2750 B.C.), the material resources and labour-power of Egypt were spent on these monstrous erections. Very early in their history the Egyptians invented the practice of embalming, and so beneath vast masses of pyramidal masonry there have been found the mummified remains of pharaohs who ruled thousands of years ago.

Dead Man's Double

A mummy might fall to pieces or be damaged by thieves; such a disaster was believed to involve injury to the surviving soul. Before the mummified corpse in the stone-built tomb a statue of the deceased was therefore placed, to be regarded as a "double," or extension of his body. So long as the statue continued to exist, the soul of the man lived on in the land of the shades. Sometimes, to ensure survival, not one statue but many were carved and hidden in small chambers cut in the rock behind.

On the walls of the burial chamber they painted pictures, showing the dead man as very much alive, going to war, or hunting game, or sitting at dinner with his wife and friends; pictures of peasants ploughing and sowing and reaping for his benefit, bakers and brewers preparing his bread and barley-brew, women weaving cloths for him to wear, cobblers making his shoes, shipwrights toiling in their yards to convey him and his family in comfort down the Nile.

This painted world of make-believe was viewed in much the same way as the statue-double—as an extension of the real. It tells the archaeologist and historian nearly all that is known of the ways of the Egyptians of four or five thousand years ago.

As early as 4000 B.C., and probably very much earlier, the Mesopotamian plain was dotted with brown-walled cities, each surrounded by orchards and date palm groves, wheat-fields, and meadows wherein were pastured oxen and buffaloes, sheep and goats.

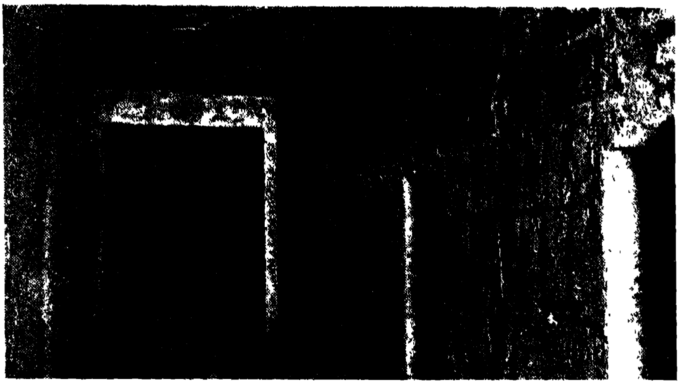
City Temple

Within the city the most prominent building was the temple, dedicated to the local god. This usually took the form of a ziggurat, or staged tower, erected on a high platform or artificial mound, and reached by wide stairways. Some ziggurats were mighty edifices, and it has been suggested that they represented an attempt by their builders, the Sumerians, who were originally a mountain folk, to reproduce by artificial means the environment in which their ancestors had worshipped. The most famous and largest of the ziggurats was that of the god Marduk at Babylon, generally supposed to have suggested the account of the Tower of Babel mentioned in Genesis.

Mud-brick Palace

Close to the temple, and on the same mound, was the palace of the city lord or king, built of mud bricks like all the other buildings, but decorated occasionally with stone carvings, and often with colour-glazed bricks, copper plaques, and carved or painted frescoes depicting pastoral scenes or the king's splendid triumphs over his enemies.

Outside the sacred enclosure in which stood temple and palace were the jumbled homes of



A CORRIDOR IN THE TOMB of Rameses IX, at Thebes. The corridor is one of several leading to the central tomb chamber.

the people, built of brick or earth, with flat roofs. Those of the middle classes were in two storeys with rooms opening off a central courtyard, the ground floor being taken up by the reception room, servants' quarters, lavatory, and private chapel (beneath whose floor was the family burial place) : upstairs were the living quarters.

The dwellings of the poorer classes were generally smaller and of one storey only. Windows were few, to secure coolness and privacy ; and as a rule there was none on the ground floor giving on to the street. Furniture comprised mats and carpets, chairs and stools, low three-cornered tables, and beds with string mattresses. The better type of house had drains leading down into cesspools. Water was obtained from public wells in the street. Oil lamps provided illumination.

Slave's Rights

At the head of each small city state was the king. Below him, society was divided into an upper class of priests, government officials, and the like ; a middle class of subordinate freemen ; and a numerous class of slaves. The slaves were the absolute property of his master, and could be disposed of as the master willed. They were branded or tattooed, and wore a distinctive dress, and any property they might come by belonged at law to their master.

Nevertheless, Babylonian slavery would probably have compared favourably with that which disgraced America and Africa into the 19th century. In practice, the slave held property. He was exempt from military service, though not from periodical or occasional forced labour. If he married a free woman, his children by her were born free. If a slave girl bore children to a freeman, she and her offspring were entitled to their freedom on his death.

Women's Independence

Women seem to have enjoyed a considerable degree of independence. Monogamy was the general custom, but a second wife was allowed when the first proved barren. The wife kept possession of her dowry, and could engage in business on her own account, even to the extent of keeping a tavern. Women became priestesses -the high priestess was called the " Bride of the God "—and abbesses of convents of nuns. Temple prostitutes were not despised, but regarded as devotees who had made to the god the most precious sacrifice in their power. There were unpleasant elements in the Babylonian civilization, such as a husband's privileges of divorce, and his right to hand over his wife to a creditor for a maximum period of three years in payment of his debts.

HOMES OF THE EGYPTIAN PLEBS. The workers who quarried the stone for the tombs of pharaoh and noble lived in box-like homes, surrounded by a strong wall, as can be seen from this illustration of an excavated village near Tel-el-Amarna. Each house contained a front room (shared with domestic animals), living-room, bedroom, and kitchen.

From "The City of Akhenaten" Egypt Exploration Society

The spades of the archaeologists have revealed much of the life of that far-distant time. The completest picture is afforded by the Code of Hammurabi, who, about 2100 B.C., ruled over the kingdom of Babylonia, into which the small city-states had become merged. Engraved on a *stele* (upright stone slab) now in the Louvre in Paris, the Code summarises the principal laws then in force. It contains regulations concerning commerce and agriculture, and the treatment of women and children and slaves. It fixes the wages of labour and the hire of cattle and transport. It fixes the fee of a doctor who has opened a tumour—and also provides that if the doctor bungles his job and the patient dies, the doctor's hands shall be cut off. A builder must die if the house he has built falls and kills the householder. Robbers caught breaking into a house are to be executed in front of the breach they have made. Those who take advantage of a fire to plunder the house are to be thrown into the flames.

ACROBATIC GRACE. This vivacious little figure, painted on a sherd, is typical of the "cabaret dancers" of the days of the Egyptian empire.
Turner Museum

Judging from the tomb paintings, harpists (left) were much in evidence at dinner parties in Middle Kingdom Egypt.
From Newberry "Beni Hasan" Egypt

The Deluge

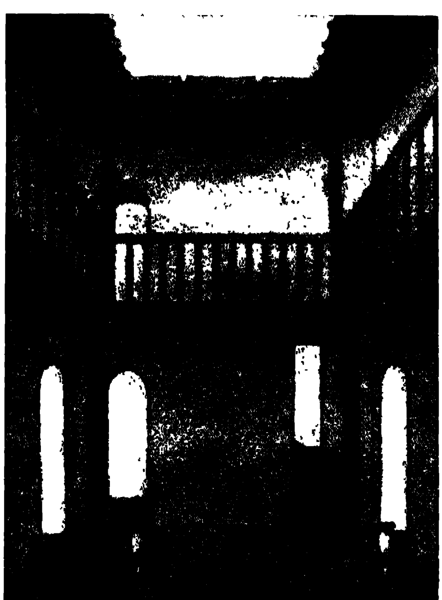
In common with most other ancient peoples, the Babylonians had their epic stories. The best-known of these tells how Gilgamesh, tyrant-king of Erech, is greatly disturbed by the sudden death of his bosom friend, and sets out to discover the secret of eternal life. He comes at last to the abode of Uta-napishtim, the Babylonian Noah (the Genesis story of the Flood is usually supposed to owe much to the Babylonian legend), who, having survived the Flood, must surely possess the secret. Uta-napishtim, however, gives Gilgamesh cold comfort :

"As long as houses are built and brethren quarrel," he says, "as long as there is hatred in the land and the waters run to the sea, so long will death come to every man."

"How then," asks Gilgamesh, "did you obtain the life you enjoy in the assembly of the gods ?"

In reply, Uta-napishtim tells him the classic story, the so-called Babylonian account of the Deluge. When the gods had determined to drown humanity, he was warned of their design by the god Ea ; and in obedience to Ea's command he built a barge with a deck-house of seven storeys, each with nine rooms. Into this he entered with his family and property, and so managed to ride out the storm which destroyed the rest of mankind.

Six days and nights the wind continued, the deluge and tempest raged. At daybreak on the seventh day the storm abated, the deluge ceased, the sea was lulled.



IN A BABYLONIAN HOUSE. This reconstruction of the dwelling of a middle-class citizen of Ur of 2150 B.C. is based on actual discoveries. Note the central court open to the sky.
Courtesy of Joint Expedition to Ur

The Ship Grounded

Opening the hatchway of his barge, Uta-napishtim looked out on to a world in which there sounded no human voice ; all mankind had returned to clay. At last the ship grounded, and he let out a dove and then a swallow. Both returned. Next a raven, and "the raven went and saw that the water had gone down, and came near the ship, croaking and flapping its wings—and

returned no more." So Uta-napishtim emerged from his ark, and promptly offered up sacrifices to the gods in gratitude for his preservation.

The story ended, Uta-napishtim tells Gilgamesh of a herb which possesses the power of making old men young, and with that the king has to content himself. This plant is stolen from him by a demon in the form of a serpent ; and the epic concludes with Gilgamesh confronting his dead friend, who tells him of the region where he dwells in misery with his fellow-dead, " whose food is dust, whose bread is mud, who see not the light . . . "

Ishtar the Goddess

Another old Babylonian story concerns Ishtar, the mother-goddess, goddess of love and of war. She loved a mortal (so runs the tale), the shepherd Tammuz, who kept his flocks on the mountain-side. One day the youth was slain by a wild boar and descended into the land of the shades. Ishtar was inconsolable, but soon bethought herself of the marvellous spring that gushed up beside the palace of Allatu, the grim queen of the underworld—a spring that possessed the power of restoring to life all who were dipped in its waters. Down into Hades she went ; and at each of its seven gates the porter demanded some of her garments and ornaments, until when she arrived at last before Allatu she was naked. Flinging herself on the dread queen, she strove to obtain by force her consent to resort to the waters of the healing spring, but Allatu was too strong for her and she was handed over to the tormentors.

ISHTAR. Wall relief at Carchemish of the Babylonian mother-goddess.

Meanwhile, in the world above, during the absence of the goddess there was neither marriage nor giving in marriage ; and at last the gods, fearful that they might be left without worshippers, commanded Allatu to release Ishtar and give her what she sought. So Ishtar returned with Tammuz; as she passed through gate after gate, she received back her anklets and bracelets, earrings and necklace, tunic and girdle. At last she emerged from the underworld, and the mourning of her worshippers was turned into joy.

Every year the drama had to be re-enacted ; every year Tammuz was believed to die, and every year Ishtar was supposed to go down to the shades and return with him triumphant in the springtime. The story is probably a nature myth, symbolical of the coming of spring after the long winter sleep. But to those Babylonian girls of long ago, and the women whom Ezekiel saw "weeping for Tammuz" in the porch of the Temple at Jerusalem, the story was vitally, eternally true.

LESSON 4

Early Civilization in Crete and Mycenae

While the succession of early pharaohs built each his pyramid tomb and was laid to rest in it, four hundred miles away across the sea Cretans were closely paralleling the Egyptian achievements in culture.

Endowed with fertile soil and a temperate climate, Crete was very early the home of peoples who used stone implements of an advanced type, were acquainted with the arts of pottery and weaving, and worshipped—judging from their idols of stone or clay that have been preserved—a female divinity, a goddess of fertility. By 4000 B.C. the Cretans were passing out of the New Stone Age into that of Bronze, when they had metals, splendid pottery, and seals whose carven facets tell much of the life of their owners. The cultural climax of this period, generally called the Minoan (after the Minos dynasty that ruled in Knossos), was reached between 2100 and 1600 B.C.

During this Minoan period the chief city states were those of Phaestus and Knossos, and from remains unearthed by archaeologists, in particular by Sir Arthur Evans (1851-1941), it is evident that they were highly civilized communities, enjoying comforts and luxuries unparalleled in the ancient world. The princes lived in palaces or government buildings, each with a labyrinth of rooms grouped about a central court ; there were brightly-coloured frescoes, tiled floors, and well-designed systems of lighting, ventilation, and drainage. The Knossian system of sanitation was far superior to any seen again in Europe until the 19th century. Beyond the palace walls were the dwellings of the people, built of stone or brick or wood, with plastered walls and flagstoned floors, arranged in neat rows bordering five-foot-wide streets. Many were of two or more storeys, and had six or eight rooms.

In vivid gem engravings, frescoes on the palace walls, and earthenware statuettes and plaques, the Cretans of three or four thousand years ago here left us their portraits. The men seem to have generally worn nothing but a coloured loin cloth, although sometimes dignitaries appear in rich cloaks and headdresses. Both sexes constricted their waists with tight belts. The women—slim figures, lithe and vivacious—favoured large and shady hats trimmed with ribbon, and very low-necked dresses, with puffed-out sleeves, wasp waists, and flounced skirts. Only their bare or very lightly-veiled bosoms differentiate their clothing from some kinds worn in the 20th century. They seem to have enjoyed a considerable degree of freedom, for they are pictured sitting among the men at religious festivals, dances, and tournaments.

FRAGMENT OF A SILVER VASE showing the defence of a Mycenaean town. Singers, archers, and spearmen make a sortie, while women gesticulate from the battlements.
From Ephemeris Archaiologike, Athens

On gala days the Minoans crowded the bull-ring that lay within the palace walls, to witness the exciting sport—to cheer the youths and girls who flung themselves in the paths of the charging bull, gripped his horns, and swung themselves high above his head. In the air they turned, alighted on the beast's heaving back, sprang again, then somersaulted into their partners' arms. Sometimes the bull's onset was too swift, the nimble limbs were not quick enough. Even so, there seemed no dearth of men and maidens ready to risk their lives in this fashion. (*See* illustration at foot of p. 2109, also the Minoan bull's head in p. 1365.)

The Labyrinth

It is thus easy to account for the legend of the minotaur in the labyrinth of the monster, half-bull, half-man, kept by King Minos and fed on the tribute of youths and maidens demanded every nine years from Athens. The name "labyrinth," given to the sprawling palace because of the *labrys* or double-headed axe appearing in its ornamentation, came to be used of any confusing series of buildings or passages. There may well be other elements of truth in the ancient story that bright-eyed Ariadne smiled on stalwart Theseus and rescued him from a bull-god, or from a priest who wore a bull's-head helmet to offer up the sacrifice of captives to make a Cretan holiday.

The Cretans of the Minoan age appear to have worshipped the mother-goddess whose cults were widespread in the ancient world; remarkable statuettes at Knossos reveal her with snakes in her hands. A beginning has been made of translations of their script, of which examples were found at the outset of the 20th century.

FASHIONS OF LONG AGO. Left, a Mycenaean priestess as represented in a fresco at Tiryns, on the Greek mainland. Right, the so-called snake goddess, the most exquisite product of pre-Hellenic art, from Knossos, Crete.
Rodenwaldt. "Tiryns." and Boston Museum of Fine Arts

Crete's Influence

The island of Crete exercised immense cultural influence throughout the eastern Mediterranean region. At Mycenae, Tiryns, and elsewhere on the mainland of what later became Greece, remains of palaces have been uncovered whose design and decoration are strongly reminiscent of the great structure at Knossos, with the addition of massive walls and fortified gateways.

SPORT AT TIRYNS. Hunting seems to have occupied much of the time of the Mycenaean chieftains. This fresco from the second palace at Tiryns, dating from about 1200 B.C., shows a boar being coursed by hounds. The style of the drawing is typically Cretan or Minoan.

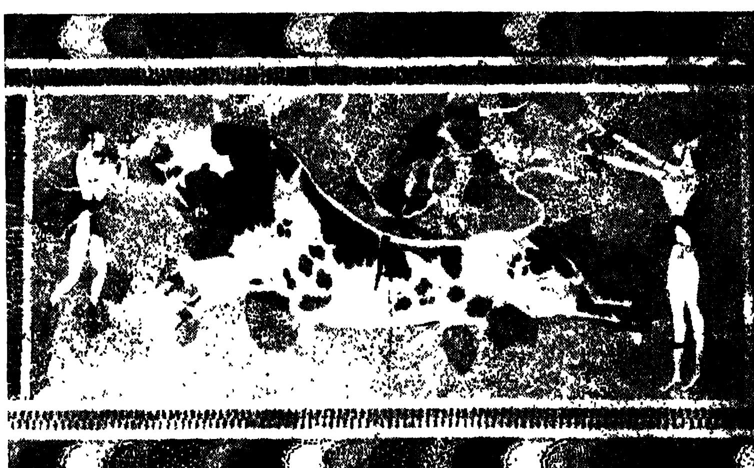
From Rodenwaldt "Die Fresken des Tiryns"

The relationship of the Cretan and Mycenaean civilizations is not yet plain. Until about 1950 it was usually, not invariably, assumed that the Mycenaean power on the mainland represented a colonial offshoot of the Minoan, which rose to its own height after the destruction of Knossos by earthquake or invasion about 1400 B.C. The most recent discoveries suggest that the ruling caste in Crete was for a period actually Mycenaean, and therefore that the power of Mycenae was established much earlier, and extended much more widely, than had hitherto seemed likely. The newly-read tablets at Pylos, the legendary home of King Nestor, chief counsellor to Agememnon, appear to list, among the slaves, captive women and children from Crete itself and from many other parts of the Aegean.

The Achaeans

Be that as it may, the Mycenaean root or branch of their joint civilization did not outlast the Minoan for more than a century or two; in the period described by Homer, dating from about 1200 B.C., a new race of rulers, the Achaeans, were firmly established in Mycenae and Tiryns and even in a rebuilt Knossos. Idomeneus, the Achaean king of Crete who sailed with eighty ships to Troy as an ally of Agamemnon and Menelaus and Nestor, may represent this new phase in the history of the island. That he was called the grandson of Minos is perhaps evidence not of ignorance or bardic diplomacy on Homer's part, but of a continuity of culture only recently envisaged.

Mention has been made of recent finds at Pylos. Clay tablets discovered there, with others found at Knossos itself, in the so-called House of Shields at Mycenae, and elsewhere, were inscribed with the writing which Evans called Linear Script B; deciphered by the English archaeologist Michael Ventris, this script proved to be a pre-Homeric Greek about 500 years older than the oldest form of Greek language previously known. This brilliant achievement shows that Mycenaean civilization was Greek-speaking, and provides texts contemporary with, and comparable with, texts from the nearby civilizations of Egypt and the Tigris-Euphrates area.



BULL DANCERS OF CRETE. This fresco from Knossos, depicting a youth and girls (distinguished from the former by their flesh tints) performing their dangerous turn in the bull-ring, makes the dead past live again after more than 3,000 years.

From H. T. Bossert, Alt Kreta

LESSON 5

The Heroic Age of Ancient Greece

In spite of archaeological discoveries of recent years, the people generally called Achaeans are still shrouded in mystery. It is uncertain whether they were invaders from the north or natives of an Aegean mainland. Fascinating problems are associated with the Homeric poems — their date and authorship, the place where they were composed, and so on. The consensus of opinion nowadays has returned to the belief that both the *Iliad* and the *Odyssey* were composed by Homer, a bard who some time before 1000 B.C. sang in the courts of the chieftains of Achaea or Mycenae — presumably the successors, if not the descendants, of the men who besieged Troy.

FEMININE FASHIONS. Although this vase painting dates from the 6th or 5th century B.C., it probably shows the same kind of drapery as was worn by women in the heroic age.

From Furtwängler-Reichhold "Griechische Vasenmalerei"

The Achaean picture is different in many respects from that of Knossos or early Mycenae. Life is far simpler. The kings and princes are really petty chieftains, banding together when occasion demands under a leader who is still one of themselves. Their palaces have none of the Cretan magnificence, but are homely farmhouses of the better sort, with no room for the pomp of royalty. Also, the Homeric period is one of strongly marked individualism, an age of "heroes," mighty men of valour who welcome every opportunity of displaying strength and prowess, whether in war, the chase, or raiding for cattle or women.

Chieftain and Servitors

Homer's two great epics show the chieftain of three thousand years ago seated in the sunshine of his porch, looking out to the court-yard that lies before his modest home, hoping that some news-bringing stranger will loom up and stay for supper and the night. Then he with his wife and household sit on stools or benches beside the table in the lofty rush-carpeted hall. Meat is the favourite, almost the only, dish; the guest must not be surprised if his helping consists of a whole joint of beef or side of pork. There are no vegetables, but cakes of bread and piles of fruit are served—apples, pears, pomegranates, and grapes. Wine is the drink, sometimes mixed with honey and spices. Beyond is the bedchamber of the lord and lady. The servitors sleep as a rule in the hall, their beds of skins and coverlets being rolled up against the wall during the daytime.

Between meals the lord goes hunting, or lends a hand in the stable or field or vineyard. He can do carpentering if need be, and if he lives near the shore he knows something of boat-building. His wife sits in the hall surrounded by her daughters and serving-girls, weaving at the big loom the garments for the family and household, working into the web incidents from the thrilling story that the old bard sang the other night beside the cheerful hearth. There is nothing in the nature of a harem or of the seclusion of the respectable married woman customary in Athens centuries later. Among the heroes, women are respected and treated as being nearly as good as men. When the lord goes to war or on a prolonged hunting expedition, it is quite usual for his wife to be left behind as regent.

Such a regent was Penelope, wife of Ulysses, one of the most beautiful characters in literature. The legend states that during her husband's twenty years' absence she remained faithful to his memory, resisting the importunities of the hundred suitors who established themselves at his board and intrigued with her maids. As year followed year, it became more and more difficult for her to persist in her attitude, but she still rejected every proposal,

PENELOPE, the model wife of Homeric story.
Vatican

giving as her reason the necessity for preparing a winding-sheet for her old father-in-law.

She worked busily during the day, telling the fretting princelings who watched the play of her nimble fingers that she would marry when the shroud was finished ; at night when the roisterers slumbered, she crept from her room and swiftly unravelled all she had woven during the hours of daylight.

Another story from the pages of the *Odyssey* illustrates the life of woman in the heroic age -the story of the princess Nausicaa, who goes with her maidens in a mule-drawn wain to wash linen in the stream. Arrived at the waterside, the girls unharness the mules and turn them loose into the clover. Then they tread the garments in the stream, after which they spread them out to dry on the gleaming stones. Next they bathe, anoint their bodies with olive oil, and picnic on the bank until their clothes are dry. Now they play at ball, and "Nausicaa of the white arms" begins a song. The charming story rings true across the ages. A king's daughter launders the royal linen --this detail lights up the picture of her time.

The Theme is War

There are no such happy scenes in the *Iliad*. Here the theme is war, complicated by quarrels between commanders, by stratagems and jealousies and the interventions of the gods. The climaxes are personal combats between Achaean and Trojan champions ; the Achaeans had come to recover the person of the beautiful Helen, who had eloped with Paris, son of Priam, king of Troy. Helen was the wife of Menelaus, the brother of Agamemnon, paramount king among the Achaeans.

One peaceful picture is mentioned, indeed, but it is that engraved on the shield of Achilles, made for him by Hephaestus the smith-god. There in bronze were depicted sheep and oxen in the care of shepherds who piped on their reeds ; ploughmen steering the ox-drawn share ; reapers moving through the cornfield, followed by gleaners ; children staggering beneath the sheaves ; vineyards, where grapes hang in massy clusters ; finally, youths and maidens in fine linen, who take hands and tread a choral dance.

The beginnings of Greek history are still obscure. A mist comes down on the heroic age ; iron-sworded invaders, barbarians from northern lands, press southward to the Mediterranean coastlands and islands. Minoans and Mycenaeans, Achaeans and the Dorians from beyond the Balkan hills---all have had their day and gone ; in their place are seen the Greeks, or Hellenes as they called themselves.

Greek Settlers

In Crete and Greece itself, throughout the Aegean, and in Ionia on the western coast of Asia Minor, there were dozens of Grecian settlements. In the toe of Italy these supreme colonisers of the ancient world established many flourishing towns, and, as the years passed, Sicily became thickly sprinkled with their centres. Massilia, now Marseilles, arose on a Grecianised riviera ; even on the coast of Spain there was an oasis of Greek culture and influence. Wherever the land was reasonably fertile, fresh water abundant, and climate kind ; wherever a promontory site was available, easily defended and with a free exit by sea ; wherever the natives were well disposed or too few to be feared -- there the Greek settlers, driven from home by pressure of population on the means of subsistence, hauled up their boats and made their new home. Around the Mediterranean, particularly along its northern coasts, there came into being a galaxy of Greek towns, each with its own characteristics, each with its temples, its spacious

GODS IN MAN'S OWN IMAGE. Zeus (top left), father of gods and men ; the sun-god Apollo (lower left), whose gift of prophecy made him the patron deity of states and colonies, no colony being founded except after consultation with his oracle ; and Athene, goddess of wisdom, war, and the arts, who sprang fully armed from the head of Zeus.

agora or market-place, and its lofty colonnades where men might walk and talk together.

No political links bound city-state to city-state ; there was no Greek empire, no confederation even, no oath of allegiance to a common head as in the British Commonwealth. The Greeks of Marseilles or of Tartessus in Spain had no say in the affairs of the Greeks of Syracuse or of Sparta ; history proved time and time again that Greeks could fight and enslave and massacre each other without compunction.

Yet they had a consciousness of oneness ; they were all Greeks, separated from the rest of mankind, whom they lumped together as "barbarians." They spoke what was virtually the same tongue ; they were thrilled by the same poems, recited or sung by wandering minstrels ; they had great religious gatherings and athletic displays ; they had their distinctive political and philosophical ideas ; above all, perhaps, they consulted the same oracles and worshipped the same gods.

In demonstrating the enormous influence exerted by the "general aspect of nature" over men's mental conceptions, H. T. Buckle drew a forceful comparison between the religions of ancient Greece and India. In India, he said, the works of nature are on a colossal and intimidating scale. Tremendous mountains, mighty rivers, impassable forests, interminable jungle, dreary deserts, speak to man of his feebleness and inspire him with superstitious dread. Hence the religion of ancient India is grounded in terror ; its gods are hideous to view, the monstrous creations of a terrified fancy. In Greece nature turns a very different face to man. The climate is healthy and the sun a genial friend ; the streams are small, and no mountain wears an eternal diadem of snow. The landscapes of Greece tended to give confidence, the landscapes of India tended to inspire fear.

Ideas about the Gods

The movements of ancient peoples involved the movement of ideas about the gods. Classical Greek mythology, which was more or less systematised in the *Theogony* attributed to Hesiod (a Boeotian poet who lived a century or two later than Homer), was the result of many convergent forces, of concepts aboriginal, Egyptian, Mycenaean, Minoan, Asiatic.

It is full of echoes of seasonal rites and of forgotten conquests and migrations, of local deities still immortal but demoted to the rank of heroes, of spirits of wood and stream and mountain, and of vague personifications of ideas and emotions—hate, revenge, chance, justice, victory—most of them subordinate to the gods of Olympus and their principal colleagues of the sea and the underworld. The physical beauty of the Greek scene may well have helped to rid Greek religion of primal terrors and of those more savage responses which included human sacrifice.

That Olympian religion had no creed, no code of morality, no belief selected and enforced by priestly authority ; its elaborate ceremonial was aimed chiefly at the securing of material well-being. It has been said of the civilized Greek that on the whole "he was a reasonable person, neither cruel nor grossly unjust, and he believed in gods who were very like himself." His reverence for his deities excluded servility but did not exclude humour ; even Zeus, father of gods, conqueror of giants, and wielder of thunderbolts, could be represented in popular myth as deceitful and deceived, spiteful and adulterous, susceptible to wheedling, and apprehensive that if mortal men acquired too much knowledge they would perhaps cease to honour him and his family of immortals.

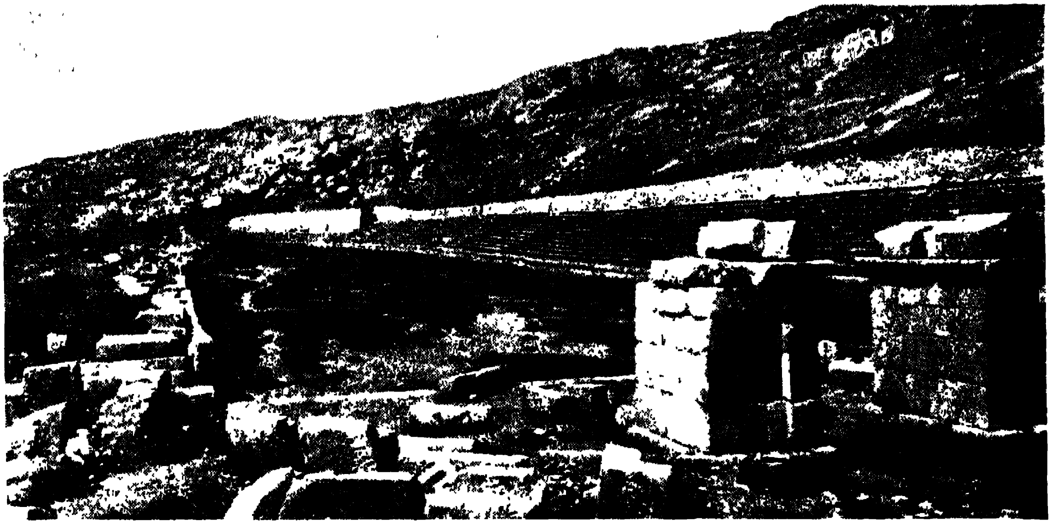
Athene

The classical concept of Athene illustrates the complicated "build-up" of a major Greek deity. Athene may have originally been the owl which by classical times had become her sacred bird ; the story of her birth from the head of Zeus reaches far back into the first twilight of religious feeling. She was a virgin war goddess (with the implication of "civilized" warfare, victoriously opposed to the wild brutishness of her brother Ares). Once she conspired to overthrow Zeus. When the giants rebelled against the gods, it was she who flung at Enceladus the huge fragment of land which became the island of Sicily. Goddess of wisdom, enemy of Troy, counsellor of Odysseus, she had given to mankind the olive, the plough, the rake, and the bridle, and had taught the craft of weaving.

Patron of fortifications and harbours, Athene was worshipped in many places other than Athens, where, in her honour and above her own city, was built the Parthenon, one of the supreme achievements of art. Beside the temple stood her colossal statue, visible far out at sea ; within it were the gold-and-ivory figure sculptured by Pheidias, and the much more ancient palladium or small sacred image which was the real object of reverence in the shrine.

Other Great Olympians

Like Athene, others of the great Olympians were, so to speak, heads of departments of existence and experience, as well as patrons of particular localities. The sailor relied on Poseidon, the poet and musician invoked Apollo and the Muses, the soldier sacrificed to Ares before battle, the farmer prayed to



WHERE GREEK MET GREEK. One of the principal centres of Greek life was Delphi, which was not only the main seat of the worship of Apollo but also the scene every four years of the celebration of the Pythian games. Here are the remains of the great stadium of the 5th century B.C. in which the games were held.

Photo, Alinari

Demeter. Hestia, goddess of the hearth, was named first in domestic rites. Dionysus ruled the feast, and Pan the wild open country. Hades or Aidoneus, and his queen Persephone, presided over the gloomy after-existence which shadowed the brightness of life in classical Greece. This great family of gods was common to all the Greeks. Among their famous shrines were the homes of popular oracles such as that of Apollo at Delphi; and the gathering-places for the great games, such as that of Zeus at Olympia.

The Mysteries

Aside from the main Olympian cults stood the so-called mysteries, which appealed to the human desire for personal salvation, isolated a particular deity for special worship, and so increased in Greek religious thought an early tendency towards monotheism. The principal mysteries were those of Demeter at Eleusis, and of Dionysus in a number of the cities. They promised the initiate some kind of communion with the deity, attained by secret, spectacular, and no doubt terrifying rites, thereby securing him a privileged position both in life and after death.

The Dionysian cult flourished in various forms, some of them orgiastic and repellent to many of the Greeks. But in Greece, Dionysus was not originally the god of wine, and one branch of his worship, the Orphic, named after the mythical singer Orpheus, was ascetic and highly moral, including a belief in the transmigration of souls, and thus in personal immortality. Some of the half-religious, half-philosophical doctrines of Pythagoras were Orphic in origin; Plato was impressed by Orphism and influenced by Pythagorean thought. The Attic drama was the product of the popular Dionysian festivals, which thus formed the cradle of the theatre in the Western world.

The philosophic systems of Plato and Aristotle led up to a Supreme Being. The Stoic philosophers based their ethics on the concept of passive matter and an active god. When the Christian revelation reached Greece, it found many educated Greeks aware of the oneness of Deity.

The Games

Mention has been made of the Olympic games. These and others—for example, the Delphic and the Isthmian (i.e. Corinthian)—drew athletes and spectators from all parts of the Grecian world. There for many days the naked contestants ran, leaped, wrestled, boxed, and hurled the spear and the discus, displaying manly beauty and athletic prowess that the world has always associated with "the glory that was Greece."

It is not known when the Olympic games began; they may have been known to Homer. The first Olympic winner whose victory was recorded was Coroebus of Elis in 776 B.C. From that time the games were held every four years without a break until a Christian emperor, Theodosius I, abolished them in A.D. 393. The Olympic truce overrode all wars between the quarrelsome city-states of Greece.

LESSON 6

The Social Life of Athens in her Prime

IN Athens of the 5th century B.C., as now, the craggy rock of the Acropolis rose above the city's clustered roofs ; away in the distance were the wooded hills that enter so largely into Grecian myth and history. Walls surrounded the city, walls with many gates and towers ; two other walls, five miles long, joined it to the port of Piraeus on the Saronic gulf.

The Parthenon

A stranger entering Athens through the principal gate, the Dipylon to the north-west, would find the street lined with small, dark, open-fronted shops, and with stalls on which were displayed cakes and bread, pottery of all shapes and sizes, fruit and vegetables, weapons of war and the chase, stuffs and sandals, perfumes and cosmetics. Perhaps evading the importunities of the salesmen, he would arrive at the agora or market-place, the centre of the city's business life. Here were pens of oxen and sheep, destined not for meat but for the altar of sacrifice, and pigs, and goats valued for their milk. Piles of farm produce would be watched over by shrill-tongued country wenches. Mounds of cheese would rise up from among jars of eels and flasks of wine. Crowds of shoppers moved in and out of the mixture of merchandise or joined the loungers in brightly decorated porticoes and colonnades to listen to vendors of news and gossip.

Leaving the market-place and making his way through a maze of winding lanes, most of them unpaved and unswept, and along streets of windowless, single-storeyed dwellings, the stranger would climb the marble steps that led upwards to the rocky platform on which were the temples and public buildings, the city's pride. Passing through the Propylaea, the great gateway of approach, he would look up at the majestic bronze statue, and then gaze in delight at the Parthenon, its statuary fresh from the hands of the sculptors, its stones glowing with colour.

Much time might be spent in sauntering about the summit of this sacred mount, exploring its temples, examining its artistic wealth, watching in the theatre of Dionysus, hearing the strains of music from the Odeum that lies below. Leaving the dwellings of the gods, the stranger could retrace his steps to the Propylaea and descend to the noise and bustle of the city. Every few yards he must step aside to avoid a heap of garbage, for the citizens had the habit of discharging their slops and other refuse into the street. Dusk would betray the absence of street lamps ; prowlers in dark doorways would make advisable the carrying of a cudgel. Another sight at a street-corner or on the steps of a temple might be a baby girl set tightly in a jar, waiting for some stranger to take her to his home in pity—or, if the gods were unkind, for death to release her from her pottery prison.

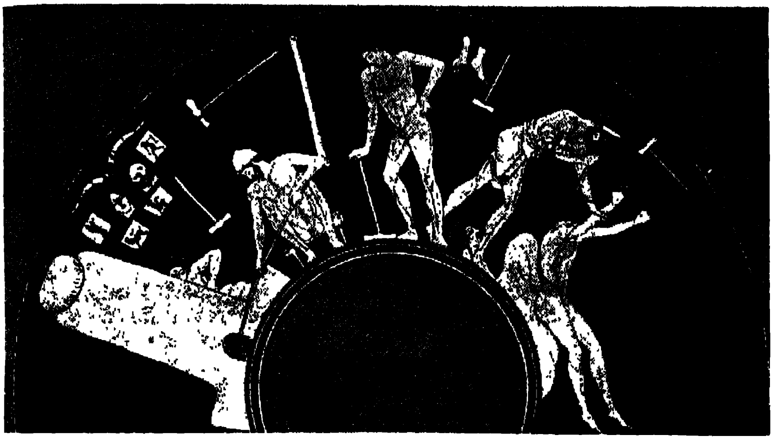
Life could be hard in Athens ; food was often dear and scarce. The visitor as he passed the homes of the common people, the shacks of timber and stucco, could look up and see the magnificent buildings erected by the dwellers in those insanitary streets and houses.

IN AN ATHENIAN SHOE-SHOP. In this vase painting shoemakers are measuring their customers for shoes by drawing the outline of the feet on the leather. An assistant is sewing leather for the uppers. Lasts, awls, and strips of leather are on the walls.

From Monumenti dell' Instituto, Rome

Women in Athens

Calling on a friend, the visitor finds him at home. The friend's wife withdraws to another room before the visitor is announced, for in Athens it was not the custom for a virtuous wife to meet any male other than her husband or near relations. No respectable woman left her home unless attended by a retinue of slaves, and then only rarely. Her day was fully occupied with supervising the servants, preparing the meals, making and mending the family wardrobe, tending her children, and performing the ritual of the daily toilette—washing and anointing, pomading and rouging and oiling. For exercise, there was flour to mix, dough to knead, beds to make.



ATHENIAN METAL FOUNDERS OF 500 B.C. On the left a workman stokes the furnace for melting the bronze, watched by an apprentice leaning on a hammer. Another artificer is chipping away roughness from a recently cast figure, the head of which lies between his feet. Tools, models of heads, hands and feet, and sketch designs of human figures and animals hang on the walls.

From Furtwangler-Reichhold "Griechische Vasenmalerei," Bruckmann A.G.

At dawn the party would break up; the visitor would take his leave, and go down to find his ship at Piraeus. Before going on board he has a look at the galleys of the Athenian navy that line the western wharf, and the timber ships and passenger boats moored close by. Despite the early hour, sailors and dockers, fishermen and merchants jostle and chatter; a curious crowd has collected about the human cargo landed by a slaver. They look melancholy, these youths and girls stolen from their island homes; the future may hold for them the silver mines at Laurium, where men work for ten hours at a time in underground galleries three feet high and three feet wide, or in pottery factories and weaving sheds.

If it had occurred to a foreigner to suggest that such a life was curiously dull to be led by ladies of the intellectual capital of the world, the reply would have been, "You mistake the position. We expect our wives to be not intelligent and well-informed, but chaste and loving, devoted mothers, and careful managers. As for intellectual companionships, we get that elsewhere. Come with me . . ."

In a few minutes the visitor would find himself in a well-furnished apartment, containing also a piece or two of marble sculpture, a few bronzes, and rolls of papyri. There, perhaps, he would see several men discussing the commercial and political news of the day, together with the latest play and poem, men's folly and women's frailty; and, lolling among silken cushions on the marble couch, a hetaira (in Greek, a courtesan, concubine), mistress of the salon, a charming figure, well coiffured and richly dressed, nibbling at olives and sipping wine from a gilded goblet. She and her kind were the embodiment of feminine grace and charm, educated and witty, worthy of their place among the Athenian intelligentsia. Sculptors, painters, poets, musicians, architects, magistrates, soldiers, and merchants were proud to be invited to her parties, and in her house to chat and flirt, dine and wine.

THE LIGHTER SIDE OF ATHENIAN LIFE. Woman was represented at Athenian dinner parties only by the hetairai, professional actresses, dancing girls, and flute players. One such dancing girl is depicted here on a cup, pirouetting before a young man who is holding her flute.

British Museum

LESSON 7

Merchant Adventurers of the Ancient World

AFTER disaster had overtaken Knossos, trading supremacy in the Mediterranean passed to the Phoenicians, a dark-skinned people occupying some two or three hundred miles of the Syrian coast and its hinterland. Theirs was a favoured country, the envy of all who beheld it. The mountain slopes were covered with cedars, firs, and pines. Then came a belt of vineyards, olive grounds, and palm-groves ; and between this and the sea stretched an alluvial plain, on which were splendid crops of corn. The climate was delightful. The mountain wall to the east for long kept out the invader.

Favourites of fortune though they seemed to be, they had no room for expansion ; their land was a narrow strip, hemmed in and intersected by mountains. There came a time when pressure of population became acute and the Lebanon mountains took on the appearance of a prison wall. But the sea lay open before the Phoenicians, and so to the sea they turned.

Their first ventures were no doubt to the island of Cyprus, dimly seen through the summer haze across 70 miles of water. Their unwieldy galleys rounded the island, and so attractive did it appear that Phoenician colonies were established in all the most favoured spots. With the growth of knowledge and experience the sailors became bolder ; steering by the stars, by mountain peaks and headlands, they voyaged along the Asiatic coast to the island-strewn Aegean—then to Crete, and from Crete to Sicily and Africa. They reached Gibraltar, and Ceuta—the Pillars of Hercules, as the old geographers called them—and for a time, no doubt, this was the limit of their voyagings.

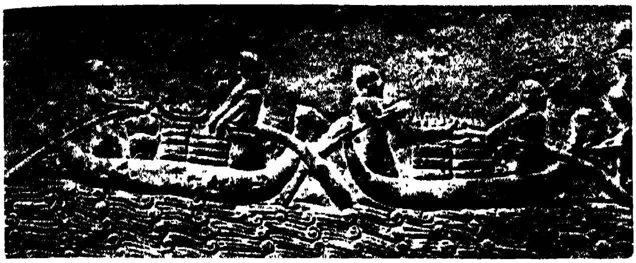
Then they began to explore along the coasts of the cold, tempestuous Atlantic. In Africa they came to the country of elephants, crocodiles, and gorillas. They settled at Gades (Cadiz) in Spain, and penetrated north until Phoenician sailors stepped ashore in the Scilly Isles. It is believed that they landed in Cornwall, and worked the tin mines there.

Their chief cities were Tyre and Sidon, in Syria. Sidon was early renowned for its wealth and for the enterprise of its inhabitants. Tyre lay to the south, some 20 miles away, and was built on an island, less than a mile long and about half a mile from the shore. One of the greatest and wealthiest cities of the ancient world, it gathered and distributed merchandise from many countries. Slave dealers waited for the landing of cargoes of youths and maidens, Greeks or Asiatics. Within the city, clerks wrote invoices and bills of lading on papyrus leaves ; store-keepers ticked off on tallies their latest consignments ; in glass-works skilled artificers produced flasks and jugs, mirrors and beads ; women sat at innumerable looms ; and down by the sea fishermen collected whelk-like molluscs, which were the raw material of the world-famous Tyrian purple dye.

There was no Phoenician empire, not even a union of city states. The Phoenicians were traders first and foremost. If they were hard-pressed by enmity or competition, they simply abandoned their settlements and made others elsewhere. They were not cowards ; they

SITE SUCH AS THE PHOENICIANS FAVOURED. Nora, in Sardinia, is an example of the site regarded as ideal by the Phoenicians a small, easily fortifiable peninsula joined to the mainland by a low and narrow isthmus. In Phoenician times the whole peninsula was surrounded by a wall with watch-towers.

From G. Patroni, "Monumenti Antichi dei Lincei"



TYRIAN SHIP. Herodotus has a story of wreckage being identified as coming from a Phoenician ship by the horse's head carved on the broken prow. That such a feature was characteristic is shown by this picture on Shalmaneser's bronze gates at Balawat of a ship from Tyre.
British Museum

could fight well when their backs were to the wall ; but they were too few in numbers to invite a war.

The nearest approach to a Phoenician empire was the loose confederacy of settlements centred upon Carthage, on the African coast near the present-day Tunis. Founded in about the 9th century B.C. by Phoenician emigrants from Tyre, Carthage enjoyed a long career of prosperity before it went down before Rome. Built on a peninsula, easily defended, with big harbours on both sides, the city was composed of narrow streets between masses of stone-built tenements, flat-roofed, and six or more storeys in height. There were a few baths for the use of the rich, but sanitation and drainage were primitive, and the packed city was ravaged time and time again by horrible plagues. Within the walls were crammed perhaps 150,000 people of varied nations and faiths. Little is known of the Carthaginian women, and this seems to suggest that they were confined to their houses, after the fashion of the respectable ladies of Athens.

Carthaginian Traders

The chief interest and occupation of the Carthaginians was trade with the peoples of the western Mediterranean and of the Atlantic seaboard of North Africa and the Iberian peninsula. Glass beads, ribbons, looking-glasses, vases—these they bartered with the barbarians for gold-dust or ivory. Carthaginians would land, it is recorded, on an empty beach, spread out their wares on the sand, and then retire to their ships. At nightfall the natives would come, inspect the goods, and place beside them what they had to exchange.

In the morning the Carthaginians would land again, and if they found the deal satisfactory, would take the gold-dust and ivory, and depart ; if not, they left the goods untouched and waited for the natives to come up to their price. Both parties to this procedure were scrupulously honest, but the natives learned by experience not to trust their persons within reach of the Carthaginian traders, who took to kidnapping if the occasion offered. Slave-dealing, in fact, was a principal source of Carthaginian wealth. Carthage was the centre where dancing-girls were trained so as to be worth in the Mediterranean market five grown men.

Many foreign deities were worshipped in Carthage, but the Carthaginians themselves held to the cults of the old nature gods of Phoenicia ; Baal-Haman, the sun-god, and Tanit-Astarte, the moon-goddess—represented, the one as a long-robed, bearded man seated on a throne, the other as garbed in a long tunic, with the vulture headdress of the Egyptian goddess Nebhat.

So represented, they seem agreeable enough, but ancient chroniclers, and the French author Gustave Flaubert (1821–80) in his novel *Salammbo*, portray another aspect of Carthaginian religion. Tanit, goddess of marriage and motherhood, was also the patroness of all that was vile ; the gentle-looking Baal-Haman delighted in sacrifice. In his temple when disaster threatened the city, fires were lit in the furnace inside his giant metal statue; then youths and girls, the most precious offerings that men could give or gods accept, were placed in Baal's wide-open arms, whence they slithered into the fires beneath his lap.

TANIT-ASTARTE. This figure from the lid of a sarcophagus is generally supposed to represent the Carthaginian goddess.
From Musée Lavigerie, E. Leroux, Paris

On the whole the Carthaginians do not appear to have been a pleasant folk, even when allowance is made for exaggerations and distortions by historians interested in the blackening of the memory of Rome's greatest rival ; yet they played no mean part in the development of the western world. For hundreds of years Phoenicians carried on the bulk of peaceful commerce ; Carthage was queen of the western Mediterranean, until after a succession of wars the city was destroyed by the Romans in 146 B.C.

LESSON 8

The Romans at Work and Play

ROME was built on and between seven hills, 15 miles up the winding Tiber, which then flowed to sea through a region of salt marshes. The city's first inhabitants were Latin shepherds, who pastured their flocks on the hillsides and watered them along the rushy margins of the river. Sometimes a trading skiff cast anchor near the bridge ; but its master, as he stowed the hides and wool, saw no sign of future greatness in the mud and wattle huts of the rustic populations. Leaning over the rail at sundown, waiting for the tide to turn, he might be excused if he spat into the water as he compared this outlandish place with the Greek cities of the Mediterranean.

And Still Rome Grew

Yet those earliest Romans had something that other peoples lacked—adaptiveness, endurance, disciplined vigour that wore down every obstacle to power. From a lowly village their settlement became a town ; then a city, a city-state. Century followed century, and still Rome grew, until at length the Roman eagles guarded a territory reaching from Scotland to Egypt, from the Atlantic to Mesopotamia. After the legions had conquered, their work became that of a police force. The empire was knitted together with magnificent roads, bridges, and aqueducts, and given a repeating pattern of temples, baths, and amphitheatres adapted from those of the Etruscans and other earlier civilizations.

ROMAN MILESTONE found near Conway, Wales.

In each tract of Gaul or Britain the process of romanisation began with the making of a road. Across the green downland crept a lengthening grey ribbon, its approach heralded by legionaries with staves and lines and measuring-rods. Labourers with pick and spade carved out two parallel ditches. More labourers removed the grass from the intervening strip and laid bare the soil or rock. Carts with solid wooden wheels, drawn by bullocks, brought loads of stones along the way already paved : small stones or shingle ; rough rubble, cemented and well rammed down ; broken brick and pottery ; huge flat pieces of rock to form a compact and level surface—so the road was built. Sometimes gravelled footpaths were laid alongside ; and milestones were set up, giving the distance from the terminal towns, and the names of the contractor, and of the emperor to whom the road was dedicated. Remains of several such roads exist in Britain to-day.

Legionaries on the March

As the road was made, the legion which made it was its first user. A fixed system of marching was established by the 2nd century B.C. Picked auxiliaries led the way, then the right wing of auxiliaries, with the baggage of both contingents behind. The legion itself followed, then its baggage-train, then the baggage of the left auxiliary wing, which brought up the rear. The legionaries were Roman citizens ; in their midst was carried the standard, a bronze eagle with spread wings, gripping a thunderbolt ; its bearer's headdress was the mask and skin of a wild beast, usually a wolf or bear.

ROMAN EAGLE. Standard of the legion, borne by an "aquilifer."

By the time of Marius (who destroyed the hordes of the Cimbri and Teutones in 102–101 B.C.) the fully-armed legionary wore an articulated metal cuirass, with under it a leathern tunic reaching to the knees, its kilt sometimes cut into broad leathern strips to facilitate movement. In cold climates, leathern breeches were worn under the tunic ; they fitted below the knee, and the rest of the leg was bare. Footgear varied between hobnailed sandals and several kinds of hobnailed boots, sometimes combined with strapped gaiters which came well up the calf and shin. The legionary had a heavy cloak, and was armed with a large rectangular shield, a sword (blade about two feet long) on his right hip, a dagger on the left, and two javelins, headed with a spike of soft iron which bent when it pierced an enemy's shield and so both hampered him and was useless for throwing back.

Civilians on the Road

Over wide areas of Europe the legionaries had, for many years at a time, only police duties. The roads grew populous with merchants followed by droves of package-laden mules, with litigants carrying their grievances

to the imperial courts, with deputations from disgruntled municipalities, poor students making their way on foot to school or university, religious teachers engaged in a pastoral visitation or bent on winning converts to their faith, masons and sculptors going to where workmen were wanted for the building of aqueduct, temple, baths, amphitheatre, or town wall. Authors would be there, with masterpieces in their wallets, seeing in anticipation the laudatory advertisements on booksellers' door-posts; pilgrims, fulfilling vows made when they lay at death's door; the sick and crippled, hobbling to find some famed surgeon or wonder-working shrine; tramps, laughing at discomfort and danger; children in the care of pedagogue or nurse; wives in creaking bullock-carts going to join their husbands in provincial camps or cities; and courtesans lolling in slave-borne litters, smiling between half-drawn curtains at every handsome man.

CENTURION in parade uniform. Decorations included torques, metal plaques, and, highest of all, an oak-leaf crown awarded for saving a comrade's life.
Cognat, "Archéologie Romaine"

Past these civilians travelled the occasional officer going on leave or returning to take up distant duty, the file of legionaries on some special errand, the imperial messenger with his passport in his belt, or the new governor with his staff and escorts, for whom everyone else must make way at the post-houses and along the open roads.

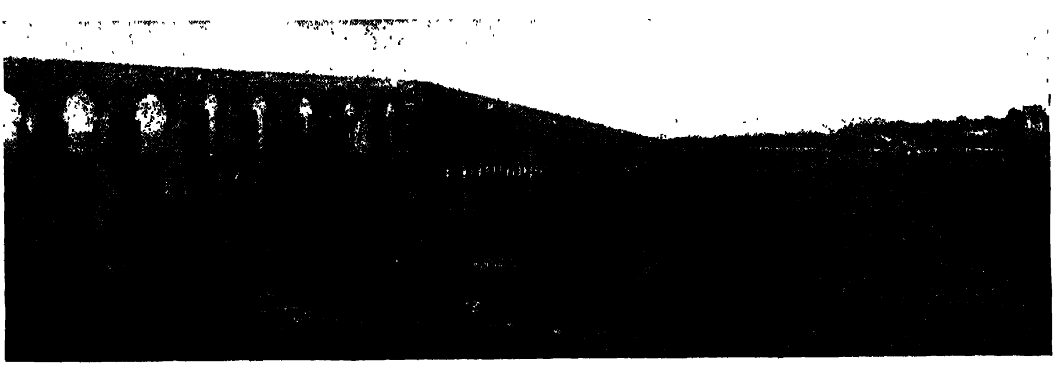
Free and Unfree

Although the legionaries made the roads and kept them in repair (with haulage by local labour), the big civil structures were the work of labour gangs employed by government or public works contractors. These workers toiled for long hours, for a pittance of pay and allowances. They quarried the mountain stone, shaped it into blocks, dragged or rolled it down the slopes, and loaded it on wagon or barge. As a result of their toil, aqueducts spanned valley and plain, amphitheatres, palaces, and baths towered above city slums. Beneath the streets were sewers and drains—pipes of lead and wood and stone.

Many, perhaps most, of the labourers were slaves, human cattle kept by the contractors, kept at work by the whip and herded at night into prison-like barracks. Others were free, either by birth or by manumission.

The gulf between the two classes was not perhaps so great in fact as it would seem in theory; and in the association called the *collegium*—considered by some to have been the ancestor of the medieval guild and the modern trade union—free and unfree seem to have met on fairly equal terms. Almost every calling had its collegium: builders and blacksmiths, armourers and plumbers, barbers and auctioneers, harness-makers, cab-drivers, and muleteers, drapers and wool-combers, scent-vendors, and even the men who at top speed cleared away human wreckage and smashed chariots and sanded the arena after each bloody "turn" in the amphitheatre.

The collegia provided sickness and funeral benefits, and opportunities for social intercourse, for a friendly gossip at leisure such as must have been eagerly seized upon by the body-wearied and soul-deadened proletarians. Business meetings in the room behind the tavern, periodical visits to the temple to sacrifice in honour of the dead brethren, processions on feast days through the streets with



CARTHAGINIAN AQUEDUCT. The arches of the aqueduct that brought water to Roman Carthage stretch for 95 miles across the plains between the mountains of Tunis and the city. Such a structure must have involved immense labour compared with a modern pipe-line.

MASTER CUTLER OF ROME. Lucius Cornelius Atimetus was so proud of his trade that he had his gravestone adorned with reliefs, illustrating it. Here is his workshop, with two assistants fashioning an article on the anvil.

British Museum (cast) from the Vatican

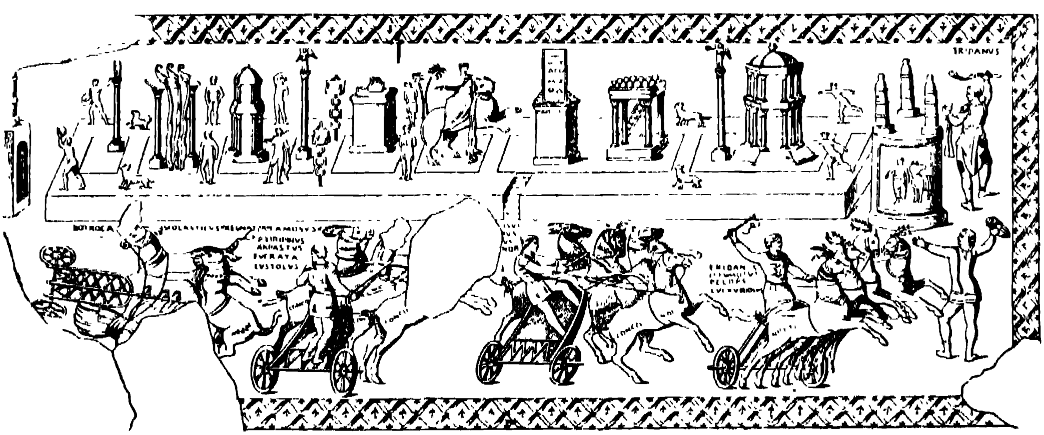
banners flying and trumpets blowing, communal meals in some chapel or hall, the last rites beside the bier of the dead on such occasions the working people had some life of their own in which to find both a sense of individuality and a sense of brotherhood.

Public entertainment of the masses by rich men in quest of power and office was a feature of certain great annual festivals ; such entertainment came to overshadow the religious side of these occasions. It was given in vast buildings—circus, theatre, amphitheatre—where immense audiences enjoyed extravagant and frequently savage spectacles, the provision of which was itself a many-sided industry.

Vast Entertainments

Shows varied from masterpieces of Greek drama (popularised to suit Roman taste by, for instance, scenic effects including the loot of conquered cities) and coarse knockabout mime and comedy (the origins of the harlequinade and Punch-and-Judy shows) to horse and chariot races, elaborate athletic contests, and a great range of games consisting of many kinds of combat. Gladiators, captives, criminals, and wild animals were opposed in pairs, groups, or crowds : fearful atrocities were part of the programme. One famous show was Julius Caesar's in the Campus Martius ; an artificial lake was dug, and on it two fleets engaged in naval battle, each manned by 3,000 convicts and prisoners of war, who were required to fight to the death. Pompey was once booed by the crowd because his tame elephants did not understand that they were expected to fight. Nero, himself a skilful charioteer, staged night chariot-races with burning Christians for torches around the course. The largest permanent building devoted to these sadistic

GLADIATOR with heavy helmet, leather breeches and greaves, dagger, and targe.



CHARIOT RACING IN IMPERIAL ROME. This mosaic from Barcelona gives a detailed picture of a Roman circus. Down the middle of the course was a rectangular barrier with various altars and statues on it, and a table with the seven oval balls used to indicate the number of laps covered by the competitors. At each end of the spina was the turning post, three cones on a tall base.

From Hubner, 'Annali'

IN A POMPEIIAN TAVERN. In this fresco from Pompeii a slave-boy is offering a cup of wine to a late arrival, whose shoes are being removed. Another guest, inebriated, is being helped out of the room, and a coloured slave is waiting on an older man on one of the couches.
National Museum, Naples, photo Anderson

amusements was the Circus Maximus, which, when finally enlarged, could seat 150,000 spectators.

Chariot-races more ordinary than Nero's roused the city to a frenzy of gambling and faction. In early imperial times the leading professional stables used for their distinctive colours red, green, blue, and white; races went anti-clockwise, usually seven times round the "spina" or central barrier. When the presiding magistrate dropped a white cloth from his box, doors were thrown open, and the teams dashed out and away. The four-horse chariots were fragile and easily upset; drivers used their whips on each other as well as on their teams, and death and injury to men and horses were part of the sport, which also involved the kind of mass hero-worship accorded to film stars in the 20th century.

As with charioteers, so also to some extent with gladiators, who were equipped in various ways to provide contrast—oblong shield and straight sword against round shield and falchion, or heavy-armed "Samnite" against light-armed "retiarius" with net and trident. Gauls, Spaniards, Germans, Africans would be matched against one another. A man overcome was at the mercy of the crowd, the victor appealing to them as to whether he should kill or spare him. There is still controversy as to whether "thumbs up" or "thumbs down" sped the fatal blow. Handkerchiefs and scarves were waved to show a plucky fighter must be spared.

Gladiators were slaves, sometimes criminals under sentence of death, or prisoners of war who chose the life as a possible means of saving money and buying freedom. Many were nothing but fighting animals; one, the Thracian shepherd and soldier Spartacus, was a military genius, who led a break-out from the training-school at Capua, occupied the crater of Vesuvius (that was in 73 B.C.: the great eruption was not until A.D. 79), and for two years defeated army after army of Romans with a force composed chiefly of gladiators and runaway slaves, finally falling in battle against Crassus.

The bloodthirsty crowd in the arena was not the whole of the Roman population; voices of famous poets and other writers survive from the period of the late republic and early empire, telling of peaceful country life among people who were no doubt good neighbours, kind masters to their servants and slaves, and in no need of the stimulus or drug provided by the arena.

LESSON 9

Religion and Philosophy in Ancient Rome

A PASSAGE in Sir James Frazer's *Golden Bough* describes the sinister associations of the lovely little lake of Nemi—nicknamed "Diana's Mirror" by the ancients—set in the Alban Hills not far from Rome:

> In antiquity this sylvan landscape was the scene of a strange and recurring tragedy. . . . In this sacred grove there grew a certain tree round which at any time of the day, and probably far into the night, a grim figure might be seen to prowl. In his hand he carried a drawn sword, and he kept peering warily about him as if at every instant he expected to be set upon by an enemy. He was a priest and a murderer; and the man for whom he looked was sooner or later to murder him and hold the priesthood in his stead. Such was the rule of the sanctuary . . .

To the elucidation of this grim custom Sir James Frazer (1854–1941) devoted a lifetime, and 12 volumes of scholarly English prose. But the cult of Diana at Nemi was not a part

of the oldest religion of Rome ; it was an early importation of the kind which finally resulted in identification of many of the much more complicated Greek concepts of deity with Roman "opposite numbers." It has been said that the Romans had no mythology ; Jupiter may have "begun" as a meteor, Vesta was the hearth-flame itself, Mars first appears as a curious blend of a pastoral "numen," or sacred presence, and a spear (or even a group of spears) shaken to secure victory in battle. Much of early Roman religion was bound up with the quiet life of home and field, and Diana herself, the forest goddess, chief deity of the Latin League, was also the helper of women in childbirth and the protectress of the young.

FAMILY GOD. The household Lar was often represented in sculpture as a dancing youth bearing a bowl and horn of plenty.

Lares and Penates

The early Latins, simple husbandmen and shepherds, worshipped a multitude of numina dwelling in stream and spring, in shady groves, on wind-swept hilltops, and having sway over flocks and herds and harvests. Other spirits dwelling within the homestead itself were Janus, the two-faced, who guarded the door ; Vesta, goddess of the hearth ; the Lares, subordinate deities of the hearth, and the Penates, guardians of the store-cupboard. Another household spirit was the Genius, regarded as a kind of twin-soul or double of the master, or even as a guardian angel. All these benevolent spirits received sacrifice and worship at appropriate times and seasons, as when there was a birth in the family, or at the corn and vintage harvests, or during the Saturnalian holiday in December—when a "lord of misrule" was chosen, and rank and work were forgotten.

The Lupercalia

A famous festival was the Lupercalia, in February, when goats and dogs were sacrificed in honour of the pastoral deity, Lupercus. Priests cut up the victims' skins, twisted them into thongs, and ran through the streets, striking with them at every one they met. Women invited the blows, believing that they helped them to become fertile. Another festival was the Fontinalia, when wells were garlanded with flowers, and blossoms thrown into the water. Simple rites, to ensure good fortune, safety, and fertility, sufficed for the practical and unimaginative Romans until they began to turn their city-state into the head of alliances and the ruler of subject peoples.

Then the Roman gods grew with the greatness of the city. Jupiter was exalted as king over the rest, and was called Jupiter Optimus Maximus—Jupiter Best and Greatest—who, with his consort Juno and daughter Minerva, became the "Capitolian" deities of Rome, identified with Zeus, Hera, and Athene of the Greeks.

Old Gods Banished

In the shrine of Vesta a sacred fire, tended by the Vestal Virgins (six priestesses who entered her service at a very tender age), was never allowed to go out save on March 1, when its rekindling marked the beginning of another year ; Vesta was recognised as the goddess whom the Greeks called Hestia. In the same way Neptune was fused with Poseidon, Ceres with Demeter, Diana with Artemis, Mars with Ares. Apollo passed into the Roman pantheon without changing his name. Many of the older Roman gods sank into minor roles ; and finally the Greek attributions and myths were followed into Roman religion by Greek mysteries, Greek philosophy, and Greek scepticism. In spite of the efforts of emperors and priests, the personalities and ritual lost their appeal ; the old gods were banished from the beliefs of the educated, although for centuries longer well

STATE GODS OF ROME. The three deities—Jupiter (centre), Minerva (left), and Juno—represented in this Gallic relief were those most closely associated with the city and empire of Rome.
Musée St. Germain courtesy of M. Salomon Reinach

VESTAL VIRGIN. The temple of Vesta was served by six priestesses, one of whom — Flavia Publicia, high priestess A.D. 247 286 - is represented here.
Temple of Vesta, Rome

into the Christian era —country folk held fast to the religion which answered the needs of Latin farmers a thousand years before. Many cultured people turned to the philosophies of the Stoics and of Epicurus.

Stoicism

Stoicism was founded in the 4th century B.C., by Zeno, of Citium in Cyprus, who taught his disciples in the "Painted Porch" at Athens; hence it was sometimes called "the philosophy of the Porch." From Greece it spread to Rome; the Empire produced three great Stoic philosophers whose writings have come down to us—Seneca (a nobleman), Epictetus (a slave), and Marcus Aurelius (an emperor). The Stoics taught that God is a spirit, all-pervading, all-wise; that all men, even slaves, are brothers ("Are they not men like ourselves," demanded Seneca, "breathing the same air, living and dying like ourselves?"), and that virtue is the supreme good. To do one's duty in the world, to endure uncomplainingly the buffetings of fate, to realize that happiness is not essential and that pain may be converted into blessing, to pass through life conscious of having done one's best - these were the stern and noble aims of the Stoic.

Epicureanism

The rival philosophy also emanated from Athens; its founder, Epicurus, was contemporary with Zeno. Roman converts included the younger Pliny and Lucretius, whose poem, "On Nature," is the chief authority for subsequent knowledge of the system. To the Epicureans pleasure occupied the place of duty among the Stoics; by pleasure they meant not licentiousness but a reasoned temperance in all things. Their ideal character was one who lived a life free so far as possible from bodily cares and mental fears. Fear, in particular, was the enemy—fear of death, fear of the gods; and fear could be banished. If gods existed, they cared nothing about mankind; death was extinction and life after death a mortal illusion. Such was their belief. Unsatisfying, perhaps, in some respects, but nevertheless a reasoned philosophy.

But to many who abandoned the state religion, the systems of philosophy offered no substitute. Hungering after emotional satisfactions, wanting mysteries to explore and a sense of salvation to be achieved, they turned to one or other of the innumerable oriental cults which trade and conquest brought into the expanding Roman world.

Other Cults

Some became worshippers of Cybele, "Mother of the Gods," whose castrated priests commemorated her love for Attis, the young and beautiful. Like Tammuz, Attis was believed to die each year and rise again. His image, a pine tree from the woods, was placed in the goddess's temple and wreathed with violets. Then the priests performed a rite of self-abandoned mourning; they leaped and spun and slashed themselves with knives until the blood poured down.

MITHRAS AND THE BULL. This bas-relief, found in a subterranean sanctuary of the god at Hedderheim in Germany, shows Mithras killing the sacrificial bull. Right and left of him stand Cautes and Cautopates, personifications of the dawn and sunset.
Les archives photographiques d'art et d'histoire

But [writes Sir James Frazer] when night had fallen, the sorrow of the worshippers was turned to joy. For suddenly a light shone in the darkness: the tomb was opened the god had risen from the dead ; and as the priest touched the lips of the weeping mourners with balm, he softly whispered in their ears the glad tidings of salvation. The resurrection of the god was hailed by his disciples as a promise that they too would issue triumphant from the corruption of the grave.

PROCESSION IN HONOUR OF ISIS. A priestess bearing the goddess's sacred vessel and serpent is followed by a scribe with the sacred book, a priest with a jar of Nile water, and a maid with sistrum and ladle.
The Vatican ; photo, Moscioni

PRIEST OF ATTIS AND CYBELE. With an image of Attis on his breast, the priest is holding a pomegranate and other symbols of fertility. Around him are ritual instruments.
Palazzo dei Conservatori ; photo, Moscioni

Others turned to Mithra, or Mithras, originally the Persian sun-god, transformed in course of time into the god of light and life, cleanser from all sin, conqueror of death and bestower of immortality. On the Danube and the Rhine, in Africa, in London and York and on the Roman wall in Northumberland, temples or other Mithraic traces have been discovered. Sculptured representations (one is in the British Museum) show the youthful Mithras astride a bull, holding its muzzle in his left hand while with his right he plunges his poniard deep into its neck. The worship of Cybele and Mithras had points in common, in particular the "Taurobolium," or baptism in the blood of the bull. In caves and subterranean dens the naked initiates crouched beneath a grating or platform of loose-joined planks. A bull, garlanded with flowers, was led on to the grating ; its throat was cut, or it was stabbed to death, and blood poured on to the waiting devotees below.

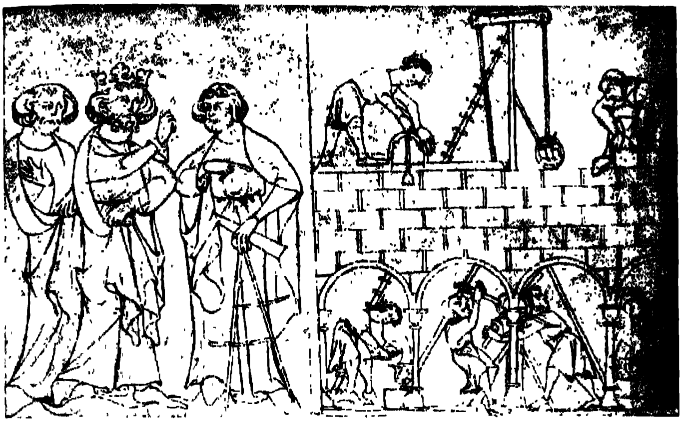
A third great cult was that of the Egyptian goddess Isis, sister and wife of Osiris, mother of Horus. Roman maidens wept at the story of how Osiris was slain and savagely dismembered by his wicked brother Tryphon, and how the loving Isis searched for the pieces until she had found them and given them decent burial. Many a Roman, perhaps a little amused by the legend, stood in reverence in her temple courts at dawn, watched the tonsured, white-clad priest "wake the goddess" by pulling aside the veil that hid her image, and felt that behind the ritual was something mystically real, eternally true.

Nevertheless, neither Cybele nor Isis nor Mithras, nor the speculations and rules of the philosophers, gave the *coup de grâce* to the ancient religion of the Roman state, which in its final stages included the paying of divine honours to dead emperors and to the genius of the reigning one. They themselves, together with the rest of the crowded Roman pantheon, were replaced by a religion already three centuries old—another religion from the East, appealing chiefly to humble folk ; it had seemed at first to be a disreputable form of Judaism, but turned out to be centred on a Crucified God.

LESSON 10

Monks and Friars of the Middle Ages

During the early days of the Roman Empire, Jesus was born at Bethlehem, in Judea, at that time an obscure kingdom dependent on the Roman power. Towards the end of the reign of Tiberius, the second emperor, Jesus Christ was crucified near Jerusalem ; his followers continued in the task he had left to them, and shortly afterwards the new faith was carried from Asia into Europe by the Jew, Paul of Tarsus. Slowly, in spite of consistent opposition (from the governing power and from rival religions) which developed at times into terrible persecution, this new faith made its way to power.



MONKS AS BUILDERS. This illustration, depicting King Offa of Mercia (d. 796) conferring with his architect over the building of a cathedral church, was drawn by, or under the direct supervision of, the chronicler Matthew Paris, about 1240–50.
British Museum, MS. of Matthew Paris's "Vitae Duorum Offarum"

took such firm root in men's hearts and lives that when the Empire was invaded by wave after wave of heathen barbarians, its faith and organization weathered the storm, while the civil fabric cracked and crashed in ruin. Goths and Vandals and Huns surged over the ill-defended frontiers, spreading death and destruction where for centuries the firm hand of Rome had ensured peace and prosperity. They ravaged country and town with fury ; famine followed in their wake, so that the miserable inhabitants whom their swords had spared fed sometimes on the flesh of their fellow-men. With famine came pestilence and depopulation. Thousands perished, and many who lived envied the peace of the dead. But the courage and devotion of Christians impressed, and sometimes began to convert, heathen kings and chieftains; they came to respect sacred emblems borne by Christian priests and bishops. Classical culture died, and Roman civilization almost perished ; what remained of it was saved by the Christian Church.

About three hundred years after its introduction into the Roman world Christianity was recognized by the emperor Constantine, mainly on political grounds, as a permissible religion. By the Edict of Milan, A.D. 313, he restored to Christians all civil and religious rights of which they had been deprived, and bestowed upon them and all other subjects of the empire the power and liberty to follow openly their own faiths.

Paganism Driven Underground

Constantine abolished the penalty of crucifixion and adopted the hitherto " disgraceful " symbol of the Cross as the imperial standard ; he abandoned worship of the old gods, attended many Christian rites and gatherings, and summoned the first general council of the Church at Nice (in Asia Minor) in 325. He himself was not baptized a Christian until his last illness, but by that time the tide of conversion was flowing strongly. For half a century the old religions dwindled ; in 390 the emperor Theodosius prohibited their practice. Temples of the gods were sacked, razed to the ground, or converted to Christian uses ; sacred trees were cut down, images broken, altars smashed : sacrifices and divination were declared to constitute treason against the state, and all other pagan rites that could not be adapted to Christian practice were condemned.

Paganism was driven underground ; for hundreds of years traces of the " old religion " were to be found in country districts in parts of Europe. There are reasons for believing that the practice of witchcraft, for which old women were burnt alive as late as the 18th century, was a form of survival of the ancient faith.

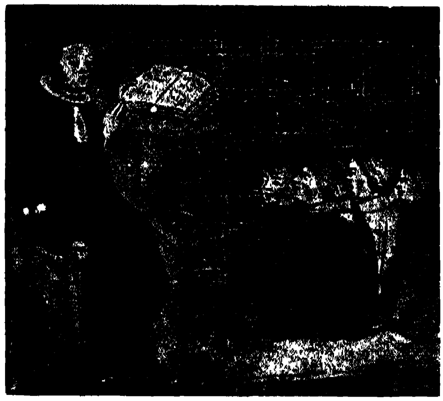
The Christian Church won the victory, and

Power of the Popes

This was true especially in the West, after the capital had been moved from Rome to Constantinople. The emperor had gone from the Palatine, but on the Vatican hill remained the bishop of Rome, who became known as the Pope (from the Greek *pappas*, father) ; to him also descended the imperial and pagan title of Pontifex Maximus (literally " chief bridge-maker "). Although discarded in 375 by the emperor Gratian as being incompatible with Christian faith, the title " pontiff " came to be applied, probably as a mark of public respect, to various leading Christian bishops ; it was first used directly of a bishop of Rome in 555. From the 11th century onwards the term Pontifex Maximus has been limited to the pontiff of Rome, or pope.

During the Dark Ages this dignitary, a sovereign of a new kind, whose dominion was based not on territory but on religious belief, gradually extended his influence and power until nearly every town and village in the west, centre, and south of Europe contained his representatives. The Empire had vanished as a physical entity ; in its place had risen a number of warring kingdoms and principalities. Among them, only the organization of the Christian Church maintained ideas of unity, of universal brotherhood, of spiritual and cultural values above and beyond the dust of battle, rapine,

and intrigue. War and hunting and possession were all that mattered to the ruling classes; men who preferred peace and contemplation often found that to uphold the Church against the state, or to take sides in the arguments that shook the Church itself, was a task beyond their strength or wisdom or patience. Not surprisingly, they withdrew to wild and solitary places; and there they frequently abandoned themselves to a frenzy of devotion and asceticism.



MEDIEVAL CLASSROOM. The methods of the teacher in medieval universities were mainly dialectical, he alone having a text-book, which he expounded to his class by question and answer. The illustration shows a 14th-century lecturer.
British Museum; Royal MS. 17, F ii

Christian Hermits

In desert and forest these anchorites—who in a kinder age might have been writers or artists or scientists—subsisted precariously on roots and berries. They might become emaciated, dirty in body, diseased in mind; some never washed, but gloried in their filth, wearing their garments to rags that dropped off their backs, harbouring lice which they would not remove, spending their days in prayer and lamentation, their nights on beds of spikes or thorns. There are records of hermits who lived in dried-up wells and in holes among the tombs, who fed on five figs a day or on corn that had been steeped in water until it rotted; of some who never lay down to sleep, who ate grass like cattle, who crawled about covered only by their matted hair; and of the stylites, who established themselves on the tops of high pillars (Gk. *styloi*), where they remained for years, exposed to the elements, leading an existence beyond ordinary understanding.

Christian asceticism found its earliest development in the Egyptian deserts, where thousands of refugees dwelt in solitary cells or in colonies. In the West, where food was harder to procure and the climate much more severe, the loosely-knit communities of the Egyptian rule were manifestly out of place. Hence, in waste lands and mountain passes on hilltops and on islands in the fens, in green valleys and beside lakes and streams, monastic societies organized on stricter lines established themselves in permanent homes. An important difference between the two types of monastic life was that in the East virtually the only activity of the monk was manual labour; in the West, some at least of the brethren undertook the keeping of records, the practice of medicine, and other occupations.

Influence of the Monasteries

The first European monasteries were founded in the 4th century, but it was St. Benedict (480-543) who gave them their distinctive form and devised the "Rule" which guided their life. The Benedictine order grew in popularity and numbers, for a monastery constituted an oasis of peace in a stormy world. The ambitious coveted the abbot's power and prestige; others gladly agreed to abide by the "Three Substantials" — obedience, poverty, and chastity—in the security of the convent: the studious saw in the cloister the only place where they could find books—St. Benedict's rule allowed for three hours' reading a day. A certain number of monks must also have been simply frightened of the torments promised to the damned; these determined to save their souls by the most obvious precautionary measures.

THE STYLITE. Fanaticism was carried to extremes by some early Christian anchorites, notably by those who established themselves upon pillars ("styloi"), where they remained sometimes for years. A miniature in the martyrology of the emperor Basil II illustrates the self-imposed discipline of St. Daniel the Stylite.
From Menologium of Basil II, Vatican Codex

At first the influence of the monasteries was almost wholly beneficial; the monks felled forests, drained marshes, cultivated wastes, embanked the unruly rivers. Many Greek and

Roman classics were preserved in monastic libraries, though they were valued mainly for their parchment, on which, after as much of the old writing as possible had been scraped off, the scribes could pen their monastic chronicle. Exquisitely illuminated manuscripts testify to the artistic skill of a small number of the monks and canons ; some monasteries had schools, for day-scholars or boarders ; and by their almsgiving the regular orders did much to alleviate the poverty and distress chronic during the Middle Ages.

As the years went by, wealth and the exercise of spiritual and temporal power began to choke religion ; monasteries became rich with money and lands bequeathed to them by pious or conscience-stricken nobles, gentlefolk, and merchants. From centres of usefulness and comparative culture, they often degenerated into abodes of formalism and sloth. But from time to time fresh vigour was imparted to religious life by reforming enthusiasts, of whom two in particular may be noted.

St. Francis of Assisi

Francis Bernadone (c. 1182 1226), son of a wealthy cloth merchant of Assisi, in central Italy, was a gay young man of fashion, who fought against Perugia in 1202, and spent a year as a prisoner of war. When starting out on a second campaign he fell ill and underwent some spiritual experience that altered his outlook on life. He gave himself up to prayer and meditation, spent his days in solitary rambling among the hills, renounced his inheritance, and thenceforth strove to obey to the letter the commands that Christ had given to his first emissaries – to minister to the sick and the lepers, and to carry no gold or silver, spare coats, shoes, or staff.

AT WORK IN THE SCRIPTORIUM. While the service of monasteries in the multiplication of books has been exaggerated, the great houses had "scriptoria," where monks or hired professional scribes (one is shown here) were provided with materials for copying books.

British Museum, Harleian MSS. 4425

Fired by his example, impressed by his joyous enthusiasm, other young men rallied about him to form a brotherhood. After they had taken the triple vow of poverty, chastity, and obedience, Francis instructed them always to show a cheerful face, to receive all comers with kindness, whether they were friend or enemy, thief or robber ; and not to accept money of any kind, whether to buy clothes or books or as payment for work or for any other cause, save when it was absolutely necessary in order to succour sick brethren. "We must not value or esteem money and coin more than stones," he said.

Towards the end of his life Francis went to Egypt to preach the Gospel to the sultan, and although he failed to convert his listeners, he at least persuaded the Muslim ruler to treat his Christian captives with more lenience. Two years later Francis died. By his own wish as the end approached, he was carried on a bier to the church and then laid, clad only in his woollen robe, on the bare ground. A pauper in life, so as the meanest of paupers he died. "Welcome, sister Death. . . ."

St. Dominic's Black-robed Friars

Contemporary with Francis was Dominic (1170 1221), founder like him of an order of friars, or travelling preachers, sworn defenders of the orthodox Catholic faith. Dominic was a Spaniard, with a Spaniard's pride and daring, and readiness to sacrifice all for the sake of a great cause. After years of study he was ordained, and then travelled from town to town, trudging always barefooted, preaching the faith wherever opportunity offered—by the wayside, in village churches and great cathedrals, in humble homes and baronial castles. Zealous disciples gathered about him as they gathered about the more genial and lovable Francis. He accepted their service, taught and trained them, and sent them out into the world as black-robed "hounds of the Lord." Before he died he had the satisfaction of knowing that Dominicans were preaching in every part of western Europe ; a few years later saw them penetrating into the interior of Asia.

The reasons for the rapid growth of these preaching fraternities are not far to seek. Unlike the monks, whose influence was confined to the immediate neighbourhood of their convents, the friars took their message to the people.

They were better educated than the parish priests ; carefully trained in the cloister before setting out on their journeyings, they returned to it at intervals to recuperate in body and mind. Being poor themselves—at least in their early days—they could sympathise with the poverty-stricken and afflicted, And their knowledge of everyday life, gained and constantly refreshed by contact with the common people, enabled them to couch their message in homely terms, understood, even enjoyed, by the simple and ignorant.

Medieval Sermon

An example of the friars' exhortations to better ways of living is this address by the Franciscan Berthold von Regensburg, who during the 13th century tramped from village to village in central Europe ; standing in a market-place or on a village green, he exposes some of the tricks of trade.

"The first are ye that work in clothing, silks, wool or fur, shoes or gloves or girdles. Men can in no wise dispense with you , men must needs have clothing, therefore should ye so serve them as to do your work truly—not to steal half the cloth, or to use other guile, mixing hair with your wool or stretching it out longer, whereby a man thinketh to have gotten good cloth, yet thou hast stretched it to be longer than it should be, and makest a good cloth into useless stuff Nowadays no man can find a good hat for thy falsehood , the rain will pour down through the brim into his bosom Even such deceit is there in shoes, in furs, in curriers' work ; one man sells an old skin for a new and how manifold are your deceits no man knoweth so well as thou and thy master the devil. But why should I come here to teach thee frauds ? Thou knowest enough thyself"

Then he castigates the smith who

"wilt shoe a steed with a shoe that is naught , and the beast will go perchance scarce a mile thereon when it is already broken, and the horse may go lame, or a man be taken prisoner or lose his life."

Next comes the turn of the traders who

"Bring from one kingdom to another what is good cheap there, and whatsoever is good cheap beyond the sea they bring to this town . . . some from Hungary, others from France ; some on ships, some on waggons, driving beasts or bearing packs." So far so good, but not content with getting a livelihood with "true winnings," says the preacher, traders swear and deceive, bluster and bluff ; "there is so much fraud and falsehood and blasphemy that no man can tell it " Then are held up to execration the butchers who sell "measly or rotten flesh, unwholesome before the slaughter or unripe of age" ; inn-keepers who vend corrupt wine and mouldy beer , bakers who use rotten corn ; husbandmen who feed their cattle on another's field or plough over his land mark ; corn-dealers who lay fine corn at the top of the sack, and the evil corn beneath ; doctors—"he who is no good master of that art, let him in no wise undertake it, or folk's blood will be on his head . . . 'O Brother Berthold,' you say, 'four times already have I had all success !' Lo ! that was but a bow at a venture. If thou wilt not let this matter go and study further in the inward art, then the rulers of this world should forbid it thee on pain of curse and banishment We have murderers enough without thee, to slay honest folk . . ."

But for most part the friars were made of quite ordinary stuff, and did not rise above

FOUNDERS OF FRIAR ORDERS. Left, St. Francis of Assisi (c. 1182 1226), who established the Grey Friars (known also as Friars Minor or Minorites) in 1210. Right, St. Dominic (1170-1221), founder in 1215 of the Dominican Order of Friar Preachers (Black Friars).

From Westlake, "St. Francis of Assisi," and (right) National Gallery, London

the intellectual and moral level of their age. Popularity brought opportunities for the accumulation of wealth ; the pristine simplicity of the grey and black brotherhoods was soon forgotten, and they became what their founders would not have had them be.

Self-denying Enthusiasts

Nevertheless the friars did a great service to the whole of Christendom, not only to the poor and sick and leprous ; their work resulted in the diminution of crime, and the fostering of a moral sense, and in the spread of knowledge and education. Neither Dominic nor Francis had much love of learning for its own sake, but both realized that in the universities was a great reservoir of youthful enthusiasm which might be tapped and sent in fertilizing streams throughout Europe.

They therefore sent to Paris and Bologna and Oxford fervent missioners charged with establishment among the scholars of "cells" or groups of evangelically-minded and self-denying enthusiasts. The friars and their message were welcomed ; before long each of

OPEN-AIR SERMON. The friars, the Dominicans in particular, carried their message into the highways and byways. Here one of the brethren is addressing a country audience in the open.

Fitzwilliam Museum, Cambridge

the great universities had colleges staffed with mendicant professors, who were at least as capable and learned as the doctors of the older foundations ; indeed, the most influential thinkers of the Middle Ages were to be found in the Franciscan grey or the Dominican black.

There was rivalry between the two fraternities. The Dominicans boasted of Thomas Aquinas (1227–74), called the "Angelic Doctor," whose *Summa Theologiae* is still the text-book of Catholic doctrine ; of Albertus Magnus (c. 1205–80), so widely read and learned that some contemporaries regarded him as a sorcerer ; of Savonarola (1452–98), the reformer and martyr. The Franciscans spoke with pride of Duns Scotus (c. 1265–1308), who drew thousands to Oxford to hear him lecture ; Alexander of Hales (c. 1180–1245), Gloucestershire parson who won the title of the "Irrefragable Doctor" ; St. Bonaventure (1221–74), the "Seraphic Doctor," mystic and ascetic ; and William of Occam (c. 1290–1349), styled the "Invincible." Much of the controversy in which these "Schoolmen" engaged now seems futile ; even that most discussed of medieval topics, the nature of abstract ideas, or "universals"– whether beauty, for instance, exists apart from beautiful objects, as the Realists averred, or whether, as was believed by the Nominalists, such a term is the name of an idea with no corresponding object in time and place– seems to lack justification for the energy spent on it.

A man ahead of his time was the scholarly Roger Bacon (c. 1214–94), the most original thinker of the Middle Ages. Born near Ilchester, in Somerset, Bacon studied and taught in Oxford and Paris, devoting all his energies and resources to the cause of science. "During the twenty years that I have specially laboured in the attainment of wisdom," he wrote, "abandoning the path of common men, I have spent on these pursuits more than two thousand pounds" [a very considerable sum in those days] "on account of the cost of books, experiments, instruments, tables, the acquisition of languages, and the like." Then he joined the Franciscans. His new superiors soon came to regard him with distrust ; they forbade their new recruit to publish anything of his researches, and for years kept him in prison.

For a brief space fortune seemed again to smile when a Pope (Clement IV) bade him write down his ideas, notwithstanding the ban placed upon his literary work by his superiors. For a year and more he toiled at his desk, and at last he dispatched to Rome his *Opus Majus*, a compendium of all the scientific knowledge of the time. The Pope received the manuscript, and Bacon was granted a measure of freedom. But Clement died, and his successor Nicholas III confirmed a further sentence of imprisonment. A third Pope released Bacon, who returned to Oxford and there died.

It is claimed for Bacon that he invented gunpowder, but it is probable that he learned of this explosive from Arab sources, the Arabs having been taught its composition by the Chinese. He attributed movement of the tides to the action of the moon, and believed the earth to be a speck in the centre of the heavens. He was among those responsible for acceptance of the idea that experiment was necessary for understanding the laws of nature.

LESSON 11

Mahomet and the Arabs

About three hundred years after the Christian religion supplanted the pagan cults, it encountered a new and far more dangerous enemy in Islam– the religion of Allah and his prophet Mahomet (more correctly, Muhammad). The outlines of Mahomet's romantic life-story can be briefly recounted. Born about A.D. 570 at Mecca, at 25 he entered the service of Khadijah, a well-to-do widow, conducted her trading enterprises, and at length became her husband.

Despite the disparity in their ages–Khadijah

EVENING PRAYER IN THE DESERT. One of the "five pillars of Islam" is prayer five times each day. These devotees have interrupted their Sahara journey to turn towards Mecca as they pray.

was 15 years Mahomet's senior—the marriage union seems to have been happy. Khadijah was Mahomet's wife, the mother of his children, and sometimes his only friend. She listened to his story of how the angel Gabriel had appeared to him in the desert and allayed his fears ; and when the angel voice commanded him to be up and doing in the name of the One True God, Khadijah believed in the call when everyone else mocked at it and called Mahomet a madman.

Slowly he made converts, chiefly in his family circle ; then a few slaves and workers joined him, until after three years he could claim 40 proselytes. There followed ten years of open preaching in Mecca, during which with growing boldness the Prophet denounced the crude idolatry of the Meccans, their immorality and gambling, their drunkenness, and above all their custom of female infanticide. "When the sun shall be folded up," he declaimed, "when the stars shall fade and the mountains be shattered into fragments, *then* it shall be inquired into for what crime she who was buried alive was killed !"

Mahomet began his mission with no compact system of theology : "There is no God but Allah" was the first item in his creed—Allah, the god or God, creator of all things in heaven and earth ; and the second and last was "Mahomet is the Prophet (or Apostle) of Allah"—in true prophetic succession with Adam, Noah, Abraham, Moses, and Jesus. Each prophet had received a message from heaven to impart to the world, and Mahomet claimed to be a recipient of divine messages, either in a state of trance or through the

HERE MAHOMET WAS BURIED. General view of Medina, the Arabian city in which Mahomet died and was buried. In the background are the minarets of the Great Mosque which contains the tomb of the prophet. Medina, the second holy city of the Muslims, is about 250 miles to the north of Mecca, where Mahomet was born.

COLONNADED COURTYARD AT MECCA, with the black-draped Ka'aba—ancient rock-built temple in the right foreground. It was at Mecca that Mahomet was born about A.D. 570, and a pilgrimage once in a lifetime to Islam's most sacred city is incumbent on every devout Muslim. In the background stands the medieval fort of Aiyad.

intermediacy of the angel Gabriel. His trances were frequent, and scribes were held in readiness to report the words that on these occasions fell from the Prophet's lips. In this way much of the Koran, the Bible of Islam, was compiled; Mahomet himself wrote nothing.

"Five Pillars of Islam"

The "creed of two propositions" constitutes one of the "five pillars of Islam" which, the Muslim doctors claim, were established by the Prophet; the others are prayer five times each day, a month of fasting (Ramadan) each year, the duty of almsgiving, and the pilgrimage once in a lifetime to Mecca. These date from different periods in the Prophet's mission, for at its commencement there was no carefully devised ritual. As converts multiplied and experience grew, the new religion took shape and was modified to suit a changing environment; what was fitted for a half-secret sect was obviously inadequate when the Prophet became the head of an Arabian state.

The last of the "pillars" shows how well Mahomet understood the needs of his people; Mecca had long been a centre of pilgrimage, and then, as now, its main industry was catering for the pilgrim crowds. Many an Arab was relieved to learn that if he joined the Prophet, he must still go on pilgrimage to the holy city as his ancestors had done for centuries before him. There he must walk seven times round the Ka'aba, the ancient rock-built temple; walk seven times round it (though not naked, as had previously been the custom), and kiss the "Black Stone" embedded in the corner, the stone that according to legend came down from heaven. (It may have been a meteorite.) Another satisfaction to the Meccans was the order that the faithful of Islam should turn towards Mecca when they prayed.

Muslim Heaven and Hell

Next to the unity of Allah—"Allah is the only God; Allah is the Eternal. He hath begotten none, nor was He begotten, and there is none of the same genus with Him"—the doctrine given most prominence in the Koran is that of the future life and the Day of Judgement. With exultant relief the converts listened in the days of persecution to the Prophet's confident portrayal of the hell prepared for those who rejected him and his teaching, a hell of everlasting fire and boiling water and rolling clouds of smoke; and with pleasure they heard him dilate on the joys of heaven—that paradise reserved for the believing blest, where they repose on couches studded with jewels of gold, dressed in garments of green silk and brocade, with bracelets of silver; where immortal children bring them vessels filled with pure drinks, causing no headache or confusion, and

fruit and flesh to their liking ; where damsels of unsurpassed loveliness minister to their pleasure.

As the ten years of missionary activity drew to their close, the hatred of the Prophet's enemies, now become fearful for their gods of wood and stone and their old accustomed ways, grew in intensity. Many of the converts were terribly punished for their abandonment of tribal deities ; Mahomet himself was threatened with death and sank into poverty. The faithful Khadijah died, believing in him to the last ; and soon afterwards his uncle, Abu Talib, who had kept enemies at bay by threatening them with a blood feud if his nephew were murdered, followed her to the grave. Never had Mahomet so much needed a powerful friend ; never was he so utterly alone.

The Hejira

When things were at their blackest, he received an invitation to go to Yathrib, a city some 250 miles to the north of Mecca, where his missionaries had been active for some time. He saw in the invitation the hand of Allah, and in A.D. 622 he managed to evade his enemies and reached the friendly city, henceforth to be known as Al-Medina, the city supreme. With this *Hejira* (migration) Mahometan chronology begins.

Welcomed by his friends at Medina, Mahomet became the city's judge and ruler, and was able to wage war against his opponents at Mecca. Two years before he died he had the satisfaction of receiving the Meccans' submission ; his missionaries were then able to penetrate into every corner of Arabia without hindrance. Yet success did not turn his head by converting him into an Oriental despot or a vulgar conqueror. Ayesha, the favourite of the several wives he married after Khadijah's death, said that he often went without food ; another writer testifies to having seen him fastening a piece of cloth tightly about his body to lessen the gnawing ache of hunger. Even when Mahomet was the undisputed head of Arabia, he might be seen sweeping the floor of his house, fetching water from the well, kindling the fire, mending his clothes and sandals, milking the goats in the courtyard, and feeding the camels, kneading flour, and doing the family shopping in the bazaar. He lived mainly on dates and water ; he dressed in a garment of coarse wool ; and he died almost penniless.

He died on Ayesha's bosom and in her house ; that house was converted into a mosque, and there he was buried. In the city of the men who loved and trusted him, beneath a black marble slab, his body lies on its right side—so millions of Muslims have believed, and believe—at full length, undecayed, the face supported by the right hand and turned towards the holy city of Mecca.

Arab Conquests

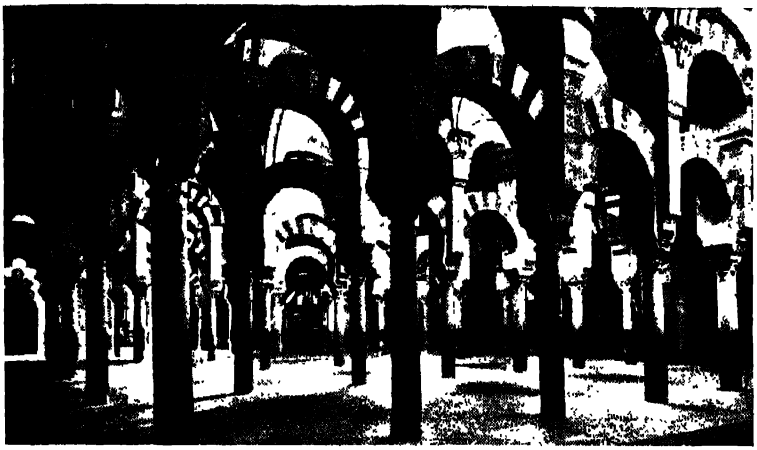
Within seven years of Mahomet's death Arab Muslims—or Saracens, as they are generally styled had conquered Palestine and Syria, Mesopotamia and Persia ; the next year saw Egypt added to their empire. They then moved steadily westward along the north African coast, firmly establishing their rule and their religion ; before the end of the first century of the Mahometan era they crossed the narrow straits at Gibraltar and entrenched themselves in Spain.

The Arabian nomads, sons of the desert, had no culture or literature ; few of them could read or write. They were formidable fighters, and their remarkable victories resulted quite as much from greed for plunder as from any desire to extend their new religion. At first they despised the peoples they conquered so easily ; all they wanted to do was to rule and enjoy the advantages of ruling. The early caliphs were capable and tolerant governors but very indifferent Muslims, for they loved wine and music—both loathed by the Prophet—and made little effort to win converts to Islam ; each unbelieving subject paid a poll-tax, and the sum raised in this way formed a substantial part of the caliph's wealth when the period of indiscriminate plunder was over.

Before long the Arab conquerors lost much of their influence to the cleverer members of the

IN A BAGHDAD SHOP. This illustration from the 13th century " Schefer " MS. of Hariri shows a shop in the Baghdad of the Caliphs.

From F. R Martin, The Miniature Painting of Persia, India and Turkey



ISLAM'S GLORIOUS MOSQUE IN CORDOVA. In La Mezquita, formerly the chief mosque of the Moors, and to-day the Catholic cathedral, Cordova has the noblest monument of Arabic religious architecture in Spain. It was begun by Abd er-Rahman in 785, and covers a rectangular area 750 feet long by 425 feet wide. The arches are arranged in 19 aisles.

subject peoples, who adopted not only the Islamic religion but Arabic names even, it is said, Arabic pedigrees. Islam knows no distinction of people or class ; and so it came about that when the conquered accepted the Koran and its language, when they became Arabs in speech and culture, there was an end of the prerogatives of the Arabs by birth.

The intermingling of the virile nomads with the less vigorous but more cultured Persians and Syrians and Egyptians had excellent results ; and for some centuries the Arab countries were remarkable for their intellectual and material achievement. Baghdad, the capital of the caliphs, drew students and scholars from every corner of the Islamic world ; its mosques were the universities of the day, thronged with men of all ages, eager to learn from self-constituted professors in many subjects, in return for such fees as their pupils thought fit to give.

Flowering of Arab Genius

In these unconventional universities the Koran was the foundation of knowledge, but this led of necessity to the study of the Arabic language and the rapidly-growing Arabic literature. A considerable amount of the classical culture of Greece and Rome that had survived in countries over-run by the Saracens worked its way up, as it were, and now became part of the recognized teaching of the Muslim schools. Transplanted into more congenial soil, the Arab genius flowered as never before ; and in mathematics ("cipher" and "algebra" are Arabic words, and our numerals are "Arabic," too) and in chemistry, astronomy, and medicine much gold of knowledge and discovery was mixed with the dross of speculation. At this time the bulk of western Europe was sunk in illiteracy ; such knowledge as its scholars possessed was obtained in the main by way of Latin translations of Arabic treatises, or by personal contact with Saracen teachers whom one or two enlightened rulers had invited to their dominions.

Moors in Spain

Baghdad constituted one horn, as it were, of the Muslim crescent that stretched from Asia to Europe by way of Africa ; at the other extremity, in Moorish Spain, was Cordova, perhaps the summit of Arabic culture and for long the centre of the only really civilized state in Europe. Set on the banks of the Guadalquivir, which was spanned by a bridge of 16 arches, the city enclosed within its walls many magnificent mosques and palaces, wide streets, spacious squares and gardens, baths and libraries, and thousands of well-built houses.

MOSQUE UNIVERSITIES. Mosques were the great universities for the dissemination of the new learning in the days of Baghdad's imperial splendour. To-day they still fulfil the same function, though instruction is mainly in the Koran. Above, students are undergoing an examination in the Mardani mosque at Cairo.

Rising high above the city's domes and roofs stood the Great Mosque, a superb specimen of Arab architecture and one of the finest buildings in Europe, its dazzling bulk of stone and gilt and mosaic occupying only a little less space than St. Peter's at Rome. More than 1,200 columns supported its roof ; its doors were covered with brass, its sanctuary was paved with silver ; and at night hundreds of lanterns banished darkness from its glittering walls.

Beneath its roof gathered teachers of medicine and jurisprudence, geography and natural history, philosophy and poetry ; their students included Christians as well as Muslims. Fair-skinned barbarian youths from France or Germany sat side by side with their more cultured dusky fellows from Barbari and Egypt, listening to expositions of the " Canon of Medicine " of Avicenna, or of the works of Averroes (1126-98), Cordova's greatest son, who took all knowledge for his province and dared to criticize not only the scriptures of Jew and Christian, but the holy Koran itself.

Moorish Enlightenment

Through Averroes, Muslim and Frank and Italian learnt of Aristotle, tutor of all-conquering Alexander and author of works on politics, ethics, rhetoric, and art. In their laboratories they busied themselves with pestles and mortars, crucibles and alembics ; they boiled and filtered and distilled, pored over the pages of the great alchemists—Geber's *Summit of Perfection*, for instance, perhaps the oldest (8th century) book on chemistry in the world—and did their best to find the Philosopher's Stone to convert base metals into gold, or that elixir of life of which one draught would give men immortality.

Muslim education was widespread ; the majority of the people of Mahometan Spain could read and write, and the learning by heart of long passages of the Koran acquainted them from childhood with the literary basis of their faith. Another evidence of Moorish enlightenment was the police force which preserved order, did duty in the markets as inspectors of weights and measures, examiners of the water supply, and sanitary inspectors, and reported cases of cruelty to children and animals. Another was the honourable status of women ; polygamy was, of course, allowed—as it was for some Christian rulers of the period—but only rich men could maintain the maximum of four wives at a time. Marriage was a civil contract, and a wife could hold property in her own name and dispose of it without her husband's permission. Both husband and wife could obtain a divorce, although the man could secure it on easier terms than his spouse. Another evidence of high civilization was the fact that the Arabs of Spain were tolerant of Jews and Christians ; frequently their nobles and rulers married Christian wives.

Fall of Granada

The peninsula was a melting-pot of races and creeds, and it is one of the tragedies of history that the process of fusion was so rudely terminated. Europe would have been well served if the Spanish Arabs had been allowed to continue to pass on the ancient culture of the nations their race had subdued and reinvigorated ; but religious fanaticism intervened. Instead of working hand in hand, Christian and Muslim fought each other with a savage bitterness. In the end the Muslim Turks stormed Constantinople, destroying the last Christian outpost in the east ; 40 years later the valiant but half-barbaric Christians captured Granada, the last surviving stronghold of the Spanish caliphate. In the west the Cross rose triumphant over the Crescent ; in the east the Crescent glittered above the fragmented Cross.

LESSON 12

Peasants and Crusaders

THE thousand years that followed the invasion of Europe by the barbarians are generally called the Middle Ages. Sometimes they are sub-divided into (1) the Dark Ages, roughly from the sack of Rome by Alaric in 410 to the period of Norman expansion in the second half of the 11th century (i.e. their conquests of England and Sicily) and the First Crusade ; and (2) the Age of Chivalry, extending to the fall of Constantinople in 1453.

Dark the first half of the Middle Ages certainly were ; art and literature, philosophy and law, were growths ill sheltered from the violence of the time. For the great mass of the people. labouring folk tied to the soil, life was much worse than it had been during the Pax Romana. They were villeins or serfs—half-way between slavery and free poverty. Forbidden to leave his native village save under very heavy penalties, the serf was the property of the lord to whom the land itself belonged. He could be sold with the land, but he could not, as a rule, be sold without it. Hence he was not an isolated unit as was the slave his predecessor ; he had roots in the soil ; his little holding, his home and family, his livestock, his pots and pans. He was exempt from one scourge of the industrial age—prolonged and undeserved unemployment.

REEVE AND REAPERS HARVESTING. The most important person in the working of a manor farm was the reeve. Chosen by the villeins from among themselves he acted as foreman, seeing that hours were kept and that all work was honestly and efficiently performed.
British Museum, Royal MSS., 2B.vii

His lot was very hard. To work from dawn to dusk in all weathers, in return for a meagre livelihood, has been the fate of the peasant in all ages ; but in the early medieval period the life of the serf was often a hell of oppression and want. He was bled by taxes, weighed down with labour dues, forced to pay dearly for the use of the manorial grindstones and cider-press, compelled to stand by while his sprouting crops were destroyed by his lord's pigeons or rabbits ; and he had to get leave for the marriage of his son or daughter.

War Without End

To the grind of toil was added almost constant danger of war and rapine. Professor Boissonade wrote :

> War was perpetual ; it died down in one place, only to break out again in another. It was the usual accompaniment of spring and summer, and let loose upon thousands of little states all the horrors of devastation, fire, and murder. Cottages went up in flames, harvests were burned, cattle killed or driven away, vines and fruit trees cut down or uprooted, mills destroyed, and churches profaned. When the peasants were unable to take refuge in the heart of the woods they were seized, fleeced, tortured, mutilated, hanged. Sometimes their hands and feet were cut off, or they were flung upon the fire ; captives had their eyes put out, women were violated and their breasts were hacked off.

Add to the horrors of this chronic state of warfare the disasters of nature—floods and tempests, bad harvests and drought ; add the leprosy and plagues engendered or fostered by the filthy habits of the time—and it is possible to obtain some idea of the life of the common people of that time. Living and breeding under such conditions, the peasantry were cruel and ignorant and coarse, victims of the most degraded and absurd superstitions. Their clothing was often of the poorest description, their food and drink sparse and of bad quality. They lived in huts and hovels of wood, wattle, or turf, lacking windows, chimneys, drains.

There were degrees of squalor ; to walk up the miry street of a medieval hamlet and, avoiding the refuse-heap just before the door, to peer into a more prosperous peasant's home, might show it to be furnished with a couple of benches, a rough table, a few earthenware vessels. Flitches of bacon would hang from the rafters, the husbandman's tools upon the walls. Fowls would scratch up the earthen floor ; pigs would root among the garbage of family meals. A rickety ladder would lead to a windowless attic, where beneath leaky thatch the inmates slept on heaps of straw or rushes.

Beyond a number of such dwellings would be the manor house, fortified with a stone wall or a great wooden palisade against marauders and rebellious peasants. Its furniture would be rather more plentiful and of better quality than that in the villagers' homes : a long table for the retainers and guests, another on a dais for the lord of the manor and his friends ; forms

HOW THE POOR LIVED. In the Middle Ages the conditions of life for the peasants were horribly squalid, as can be gathered from this illustration of a cottage interior about 1500. These hovels were of wattle and daub, with a floor of trodden earth.
From Bouchot, "L'exposition des primitifs français," by permission of Librairie Centrale des Beaux Arts

and settles and a carven chair of state ; a gay piece of tapestry hanging from the wall, with weapons of war and trophies of the chase. There would be gloom and discomfort there too, smoke from the open hearth, sooted rafters, soiled rushes on the floor.

Cultivation of the Manor

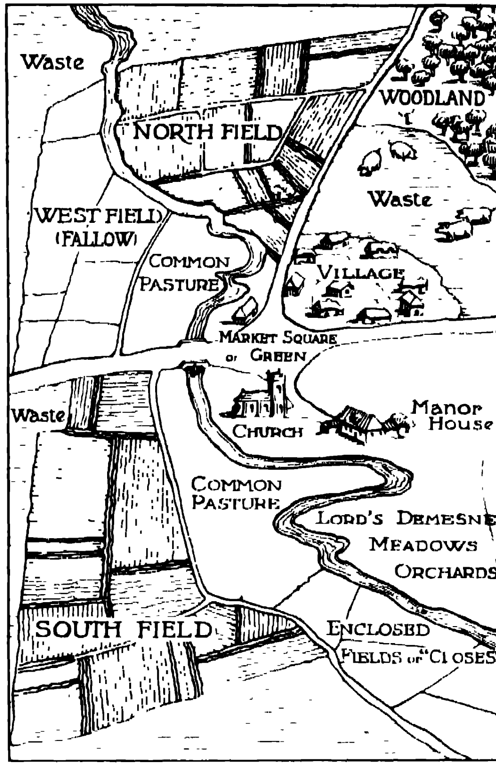
Every manor had its lord, generally a layman, but often a religious or collegiate institution. All noblemen and many gentlemen had a number of manors in different parts of the country ; they visited each in turn and ate up the stores assembled since their last visit ; between these periods of residence the steward of the manor ruled it for his master. At the manor house the manorial courts were held, with the lord or steward in the chair ; and there were stored the manorial rolls recording the dues and payments of serfs attached to the manor.

Surrounding the village on every side was cultivated land, divided into the demesne of the lord and the holdings of the peasants. Both consisted of strips the size of an acre or half an acre, distributed among three great arable fields. As a rule no two of the same holder's strips were adjacent ; they were marked off from each other by " balks " of unploughed turf. How this system originated is not known ; it may have arisen in days when more and more land was being taken into cultivation by groups of settlers, each member of the group receiving in turn the land ploughed during a day. Certainly the system prevailed during the Middle Ages in England and central and western Europe. It entailed a uniform rotation of crops ; generally while one field was sown with wheat (the bread crop), the second was given over to barley (the drink crop), beans, or peas, while the third lay fallow and helped to feed the community's livestock, which meanwhile enriched the soil with manure.

Dangerous Lives

Demesne labour was provided by the serfs. At certain times of the year, especially during the harvests, they had to work a number of " boon days " on the lord's land, gathering in his crops while their own lay ungathered, perhaps to rot ; also they were bound to labour for him on two or three days each week—the so-called " week work "—throughout the year.

In these economic conditions the medieval serfs lived their unhurried and dull or dangerous lives. See them as moving and stooping shapes in jerkins and leather breeches, out in the great fields in all weathers, tanned by the sun, numbed by the cold, drenched and dried and drenched again. They drive their ox-teams across the clearings, guide their crude and flimsy ploughs along the strips of field ; harrow and dig, sow seed, and guard the plants from vermin and



SKETCH PLAN OF A MEDIEVAL MANOR. In the centre are the manor-house, the church, and the huts of the peasantry. Two big fields are divided into strips : one is shown fallow. Pastures and closes in individual occupation line the stream. Enclosing the cultivated areas are commons, woodland, and waste ground.

birds, and in due season gather the harvest with time-honoured rejoicings.

Occasionally a shadow darker even than usual falls across the scene, as when the " Black Death " struck from the East. After devastating China and central Asia from about 1333, this plague reached Europe in 1347 by way of the Black Sea, preceded, so it is said, by thick fogs and accompanied by earthquakes, floods, drought, and famine. From Constantinople it was carried by trading vessels to the ports of Italy ; it spread with demoralising suddenness. The touch of the infected sailors was death ; friends on the quay, dockers who unloaded the cargoes, hucksters who badgered them to buy trumpery wares, women in the taverns, monks who tended them in hospital, lawyers hastily summoned to make their wills, priests who bade them repent—each and all sickened and died. The corpse slew even those who carried it through the streets and laid it in its hurriedly-dug grave.

PLAGUE IN A FARMER'S HOMESTEAD. This woodcut, by Hans Weiditz, brings forcefully home the horrors of plague and also illustrates the current belief, endorsed by Boccaccio, that animals were subject to the infection. Whether this was so or not cannot be definitely proved, but modern experience suggests that it is an exaggeration.

From Nohl, "The Black Death"

Men, women, and children went about in deadly fear; when they developed the dreaded symptoms—boils under the arms and on the groin, inflamed lungs and throat, the vomiting and spitting of blood—they sank into a stupor of despair, and in a few days, sometimes a few hours, were dead.

Many sought safety in flight; innumerable corpses lay at the roadsides and in the fields. People shut themselves up in their homes, and died in agony, unattended. Some feasted and turned to debauchery until the spectre touched them and they caroused no more. Others sought immunity by abstinence, or took solemn vows and went in procession through the streets with the relics of some saint. Giovanni Boccaccio (1313-75) tells in *The Decameron* of a few well-to-do people who, "combining themselves in a sociable manner, lived as separatists from all other company," and passed the long hours in recounting stories.

The Black Death also inspired outbreaks and revivals of religious aberrations, such as those of groups of maniacs who danced their way across the country, and of bands of flagellants who scourged themselves as they moved in procession along the roads, with tapers and banners carried before them, hoping that by such behaviour the progress of the plague might be stayed. It is impossible to say how many perished, but in parts of Europe they probably mounted to half the population.

HOME LIFE IN MEDIEVAL TIMES. Time has spread a glamour over the Middle Ages that blinds men's eyes to the harsh realities. Only among the nobles and richer gentry was there an appreciable degree of material comfort, shown chiefly in the plenty that abounded in the castle halls, in the army of servitors and attendant squires, and in the entertainment of minstrelsy. Such a scene in Geoffrey of Denmark's home life is depicted here from the 15th century "Cronicques et Conquestes de Charlemaine," by Tavernier.

Bibliothèque Royale, Brussels, MS 9066 (facsimile, van den Gheyn)

The estimate for England, which the plague reached in August 1348, by way of Dorset, is from half to one-third of the population. Villages were wiped out, towns decimated, religious houses lost almost all their inmates. So great a disaster had far-reaching economic and social effects; the scarcity of labour sent up the rate of wages and stung the landowning classes into taking repressive measures. Another result was national exhaustion, which in England and France called a temporary halt to the Hundred Years War, and thereby gave the wretched survivors of the pestilence some chance to set about raising crops without the usual summer and autumn campaigns to threaten or destroy them.

FLAGELLANTS IN PROCESSION. The flagellants were bands of penitents who marched barefooted and barebacked, scourging themselves in the belief that this would appease the wrath of God. They appeared first in the Netherlands during the Black Death: and Aegidius Li Muisis thus depicts their arrival at Doornik from Bruges in 1349. The cross on their hats gained them the name of Brothers of the Cross.

Bibliothèque Royale, Brussels, MS 13076 77

Aside from the visitations of plague and the sweep or eddy of warfare, there were frequent failures of crops, and diseases among cattle. Many fine and brave churchmen laboured to combat misery and desolation, and it was not surprising that the consolations of religion were of various kinds. The French historian Jules Michelet (1798–1874) wrote that "the medieval peasant would have burst if he had not believed in the Devil," and even the Christian festivals included much brutal and degraded merry-making. So, when the tremendous religious impulse of the Crusades spread through Christendom, the effect was to launch upon the eastward roads of Europe a succession of pilgrim hordes and feudal armies whose Christianity proved a flimsy screen for adventurousness, greed, and ambition among the mass of crusaders as well as among the leaders, to whom rapacity was second nature.

Massacres

When in 1095 Pope Urban II set on foot the first great expedition for the recovery of the Holy Land from the Saljukian Turks (who captured Jerusalem in 1071 and proved much more severe than the Saracens to Christian pilgrims), representatives of the chivalry of the chief European states headed the military response to his call; but a mob of civilian crusaders, men, women, and children, many of them unarmed, would not wait for the princes with their trained knights and soldiery. Led by a priest, Peter the Hermit, and a knight, Walter the Penniless, a rabble at first numbering perhaps 300,000 streamed across France and Germany, massacring Jews in the towns, plundering villagers who were at first inclined to help them with supplies.

DANCING MANIA. One of the pathological effects of the Black Death was the dancing mania which arose in Germany. Above is an outbreak as depicted by Pieter Brueghel.

After Hollander, "Die Medizin in Klassischen Malerei"

In Hungary and Bulgaria their excesses brought bloody reprisals; only two shattered divisions reached Constantinople, where they were lodged in the suburbs. Again they behaved very badly; the Byzantine emperor Alexius I Comnenus commanded them to cross the Bosporus and in Asia Minor they fell a prey to the Turks, who killed or enslaved all but a remnant, which fled back across the straits and was disarmed by the Greeks. Anna Comnena (1083–1148), the emperor's daughter, describes in her chronicle of the period a "mountain" of bones which the Turks erected as a derisive monument to the people's crusade.

The princes' crusade followed, in four main armies. The Provençals and some Italians

were led by the papal legate (Adhemar, Bishop of Puy) and Raymond Count of Toulouse; the Germans, with some from northern French, by Godfrey Duke of Bouillon and his brothers; the main body of the northern French, by Hugh Count of Vermandois (brother of Philip I of France), Robert Duke of Normandy (brother of William Rufus), Robert Count of Flanders, and Stephen Count of Chartres and Blois (father of the future Stephen of England); the southern Normans and Italians, with the Sicilians, by Bohemund, Prince of Tarentum, and his kinsman Tancred.

EN ROUTE FOR JERUSALEM. This illustration from a MS. of the Travels of Sir John Mandeville shows pilgrims setting out for the Holy Land.
British Museum, Harleian MSS

Outposts of Western Power

These names show how the courts and castles of Europe had been stirred; and although there was probably more self-seeking than religious feeling of any kind beneath the Christian banners, warriors who fought their way through Asia Minor and Syria knelt down and burst into tears at their first sight of the towers and domes and walls of Jerusalem. Presently they stormed into the city, filling the streets with slaughter of men, women, and children; then they went in solemn procession to the Holy Sepulchre and there prostrated themselves in humble gratitude and piety.

The establishment of the coastal kingdom of Jerusalem—and of the three minor principalities of Antioch, Tripoli, and Edessa, which also resulted from the First Crusade—had a widespread effect on European civilization, although these outposts of Western power were never more than shakily maintained. Their existence depended partly on reinforcements, partly on quarrels among their Muslim enemies, and partly on the military orders of Templars and Hospitallers, whose privileged position (they built immensely strong castles and held their land direct from the pope) itself weakened the fabric of the crusader states.

When Edessa was recaptured in 1144, St. Bernard of Clairvaux was appointed to preach the Second Crusade. This time the emperor Conrad III and Louis VII, king of France, marched eastwards; and thereafter many crusading armies were led by reigning monarchs. They seldom failed to disagree, as when Richard I of England took the field and antagonised his fellow-commanders; that was during the Third Crusade, launched to repair the situation created in 1187 by Saladin's victory at Hattin and recapture of Jerusalem.

The Holy City was reoccupied by the emperor Frederick II in 1229, but lost again in 1244, and not retaken by Christians until 1917. The titular kings of Jerusalem ruled for a while in Cyprus. In 1204 the Fourth Crusade turned aside and captured Constantinople, setting up a Latin dominion that lasted until 1261; the Eastern Empire was then restored, but never recovered from the blow. In the east the Muslims—Saracens or Turks—gradually reconquered all the crusaders' holdings; in 1291 the last Christian fortresses in Syria were captured.

MEDIEVAL FRIGHTFULNESS. In medieval times, for towns captured after resistance there was seldom any mercy. They were given up to pillage, as shown in this 15th century picture, and civilians were subjected to every kind of insult and injury.
British Museum, Royal MSS 20, C. vii

Results of the Crusades

In the western kingdoms the results of the Crusades were manifold. To begin with, much property changed hands when men took the Cross and sold their lands and goods to equip themselves for the adventure. In France the baronage was considerably weakened by this process, to the advantage of the monarchy. Arrived in the East, many needy adventurers became rich and powerful without the restriction of feudal controls. Great lords learned the science of fortification and siegecraft from the Greeks and Saracens; thereafter their adoption of stronger castle walls and bigger siege-trains improved their military status as compared with that of

their own vassals, for in spite of the numbers of westerners who stayed to make careers in the East, many more went back to the West, some of them laden with plunder, most of them with a new outlook on life.

At home the Crusades were the occasion of the revival of direct taxation, a device forgotten when the Roman empire collapsed ; popes and kings raised money by "Saladin tithes" or similar impositions. Kings and sovereign princes also sold many charters to their towns, so that the growth of civic liberties and the rise of the middle classes were hastened. The feeling of belonging to a particular country was also sharpened ; Englishmen, Frenchmen, Germans, Italians, met and observed their differences, the strangeness of foreigners, and of other forms of worship. The arts and crafts and learning of the East—the carving and pottery and textiles, the windmills, glass mirrors, and musical instruments, the trees, shrubs, and fruits, the games, stories, books, paintings, and maps, the medicine and astronomy and mathematics, even the Negro slaves—came into Europe by many more routes than the half-Saracen ports of Sicily and the overseas depots of the Venetian and Genoese merchants.

REPORTING FOR DUTY. Under the manorial system in western Europe during the Middle Ages the villeins or serfs held their land by "customary tenure," performing labour dues to their lord in accordance with the custom of the particular manor. This 15th-century French manuscript shows villeins reporting for work to their lord or his steward.
Bibliothèque de l'Arsenal, Paris ; Photo, Giraudon

Eventually an effect of the failure to convert the infidel by the sword was the reappearance of the Christian missionary spirit. In 1219 St. Francis went to Palestine to convert the sultan, who was then at war with the Christians ; the saint failed in his mission, but was courteously treated. Many Europeans must have found it disturbing to realize that in numerous ways the Muslim civilization was superior to their own.

Mention has already been made of another and a terrible gift of the East to the West—the Black Death, which cut the Middle Ages in two. The serfs did not always bow to the tyranny that afterwards oppressed them ; in 1358 the French peasants, maddened by the plague, by "free companies" of disbanded soldiery, and by their own lords and taxes, rose in the bloody "Jacquerie," and for a while took an appalling revenge, but they were crushed when the government and the barons regained the upper hand. In 1381 the English peasants, headed by Wat Tyler and John Ball, rose in their turn, the immediate occasion being the imposition of a poll-tax to help to pay for the never-ending war in France. The rebels entered and terrorised London ; they burned the royal palace of the Savoy, the Temple, and the Marshalsea prison, and entered the Tower, where they beheaded the Archbishop of Canterbury, who was also Chancellor, and the Treasurer with him.

The courage of the young King Richard II shone out at a critical moment ; his subsequent treatment of the rebels was much less to his credit. In country districts numerous manor houses were sacked, and bonfires made of manorial rolls. In East Anglia, where several towns were involved in the rising, lawless knights and gentlemen took advantage of it to work off private grudges. The revolt was suppressed in several small battles, and it ended with over a hundred hangings.

During the later Middle Ages the German peasantry rebelled several times ; the most dreadful of all their risings was the Peasants' War, which broke out early in 1525. During this war the rebels had some success at first ; numbers were on their side, and they are said to have destroyed a thousand convents and castles. In the end they were crushed with great severity, thousands being killed in battle or taken prisoner and hanged. The peasant had still, in the words of John Ball, the wind and the rain in the fields, the poor cloth, coarse bread, and water to drink ; his master had the manor house, the ermine, and the wine.

LESSON 13

Commerce and Industry in the Age of the Guilds

WHEN the barbarian invasions overturned organized government in Europe, and the new pattern of society emerged with its swarm of quarrelsome princes and barons, the facts of history and geography ensured the survival or new growth of towns on hill-tops, at cross-roads, by fords and bridges, and in the protecting shadow of castle and convent.

Each of these small centres of market trade and specialised occupations was subject to a lord, paying him tribute in money or produce or service in return for his protection; in course of time townsmen often banded together and by force of arms or by gifts obtained a charter of exemption from customary dues, and of liberty to govern themselves. Thus, side by side with the manorial structure of society, the towns developed the beginnings of commerce and industry, providing refuge for many who found village life too unrewarding, and shaping a new political power in the national organism.

Merchant Guilds

Behind town walls the burghers developed their tiny commonwealths, built churches, and established schools; many a guild-house or market-hall survives as evidence of their prosperity and civic pride. The government of these free towns and cities was in the hands of the wealthier and more influential burgesses, who formed from among their number executive councils, which later developed into, or existed side by side with, what came to be styled "merchant guilds," powerful associations of the principal landowners and merchants. These guilds varied in form and function, but their main motive always was to ensure that no one outside the guild should trade in the town and enjoy its privileges except with the consent of the guild.

MEDIEVAL MARKET AND STREET. Taken from a history of Charlemagne illuminated by Jean le Tavernier in 1460, this drawing displays contemporary town life. Inside the city gate is the money-changer, and outside are traders' stalls.
Bibliothèque Royale, Brussels MS. 9066

In other words, the guilds were powerful close corporations, keeping in their hands most if not all of the better-paying trade of their towns.

Each member of a guild paid an entrance fee, and other dues from time to time; he was bound to observe guild rules and at least to appear to uphold prevailing conceptions of commercial morality. In return he had a fair share of the trading monopoly and enjoyed a number of social advantages. Guildsmen who fell on evil times were assisted from the guild-chest and by levies on other members; daughters of poor guildsmen were dowered for marriage or the convent; sick members were visited, and members' funerals were likewise the concern of the guild, which paid for masses to be said for the repose of the souls of the departed.

SHOPS IN THE 15th CENTURY. This illumination from a 15th-century Bible shows four shops, each trade being under the tutelage of its own craft guild. The draper (left) is making clothes for sale. The grocer (right) displays a sugar loaf. The barber is shaving a client. Behind, a furrier is at work in his shop.
Bibliothèque de l'Arsenal, Paris, MS. res 5062

master's apprentices was restricted, according to the state of business and future prospects in the craft.

Like the guild merchant, the craft guild was monopolistic, but in the Middle Ages monopoly did not imply artificial scarcity and private profiteering. Regulation by appointed authority was expected and willingly accepted; free competition was regarded as economically unsound and morally reprehensible; a man was not "allowed to do what he liked with his own." Some results of the system were bad, but the craft guild prevented fraud—"false work" as it was called in those days and enforced the observance of certain standards of production. Guild officers saw that members were equipped with proper tools and materials and had proper qualifications; they checked waste and investigated complaints from or against their members; they forbade night work, because badly-lit workrooms made it hard for the honest workman to do his job properly, and easy for the scamp to turn out "false work" undetected. In some places work after 6 o'clock on Saturday evenings was also forbidden.

The guild merchant and the craft guild performed many of the functions of the present-day friendly society. To his guild the member

Craft guilds, associations of all the persons engaged in a particular industry in a town, came into existence somewhat later than the merchant guilds. Commerce precedes organized manufacture in social evolution, and it was long before the market was large and settled enough to warrant "division of labour."

Craft Guilds

The first craft guilds in England were those of weavers and fullers of woollen cloth; in course of time the various trades of most of the large towns were organized on guild lines. Weavers and clothiers, dyers and cobblers, smiths and saddlers, goldsmiths and vintners—every trade with more than a handful of practitioners had its guild, supervised by an elected warden and consisting of masters, journeymen (who worked for masters but hoped in due time to become masters themselves), and apprentices (or journeymen in the making). Apprenticeship was long—in London the period was seven years—and almost always insisted upon; the number of any one

CRAFTSMAN IN GOLD. In this miniature painting of 1480 a master goldsmith of Ghent and his wife are displaying rings and gems to customers. In the showcases are pieces of plate, necklaces, pendants, and other articles of the craft.
Victoria & Albert Museum, S. Kensington

turned when sickness laid him low, when his house was burned (a very frequent occurrence in towns of timber) or burgled, when he lost his tools or his livestock strayed away. To his guild he turned likewise when he fell into:

"any mischief or poverty, by God's sending or by any chance of the world and not by his own folly or riotous living. He shall have of every brother and sister of his guild every week a farthing"—so runs one of the old ordinances—"and these farthings shall be gathered at every month and delivered forth to the needful man, in honour of Christ and His Mother and of all Christian souls."

Then, too, the guild meetings—for business, when the guild-chest was solemnly unlocked, the members standing bare-headed, and on more convivial occasions when the guildsmen supped together in hall or staged some religious play or pageant—provided welcome breaks in the daily round; and to be elected a guild official was a laudable ambition in a world closely circumscribed by custom and tradition.

Economic Ills

On Sundays and feast days guildsmen marched in gay procession, banners flying, to their parish church; localisation of industry within a town meant that members of a craft guild were generally near neighbours. They worshipped together in a place reserved for them or in their private chapel, perhaps occasionally glancing with pride at the stained-glass window provided by their guild.

There was plenty of room for disagreement between masters and journeyman, for tyranny over apprentices, for jealousy within a trade, and for quarrels about work which could be claimed by more trades than one. Town government tended towards oligarchy, merchants grew to look down on craftsmen, party strife outside the town might be echoed within it, as during the English wars of Lancaster and York; but there was good to be found in that noisy crowded life, and there have been those who looked back with regretful eyes on the guilds of the 15th century. Just after the First World War (1914-1918), for instance, "Guild Socialism" was suggested as a cure for economic ills; its basis was envisaged as industrial self-government by guilds of a form wider than that of the trade union.

Leagues of Merchants

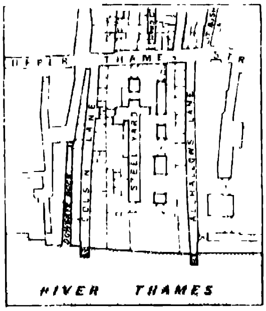
Just as tradesmen and craftsmen within a town found it advisable to unite in closely-knit fraternities, so merchants whose business lay with countries oversea naturally combined in associations for mutual support and defence. With the widening of the market and the growth of international commerce of these associations, merchants and trading cities grew in size and number. One of the earliest was the Hansa of London (Old High German: *hansa*, band of men), which early in the 13th century included the principal towns of the Low Countries and succeeded in confining to its members a considerable proportion of English overseas trade. Another early Hansa was that of "the men of Cologne in London"; Richard I on his way back from captivity in Austria granted them permission to trade over the whole of England, and at one time practically all German merchants doing business with the country were included in this association. The greatest of such organizations was the Teutonic Hansa, which began as an alliance of trading communities of the Baltic seaboard under the presidency of Lübeck.

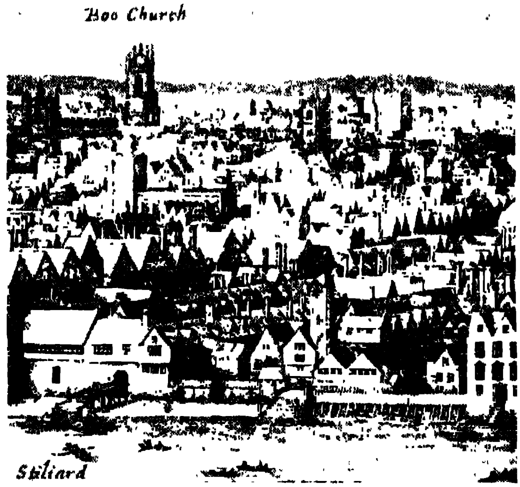
AUTOCRATS OF NORWEGIAN TRADE. **For two centuries, mid-14th to mid-16th, the Hanseatic League in Bergen held a monopoly of overseas trade by the aid of their garrison of aggressive mercantile celibates lodged mainly in the so-called German "bridge," a long row of wooden houses on the north side of the harbour, some of which are still preserved along with many of their original furnishings.**

Reconstruction by R. Christiansen from Schafer, "Die Deutsche Hansa," Velhagen & Klasing

Hansa Towns

The Phoenicians of the North, as the Hanseatic traders have been not inaptly called, had "komtors" or "counters" at Lübeck and Hamburg, Cologne and Bruges, London and York, Wisby on the Swedish island of Gottland, Bergen in Norway, Novgorod in Russia, and smaller settlements in the Baltic region. Each of these counters





LONDON'S STEELYARD. The Thames-side fortress-depot of the London merchants of the Hansa is shown in this engraving. Above is the plan of the site.

was virtually a state within a state, containing within its strongly fortified walls workshops and warehouses, common-rooms and dormitories, cellars and kitchens and a garden ; its staff ate together, slept together, worked and played together, and lived the lives of commercial monastics. Usually they served at a particular depot for a number of years, and then returned to their home town or were drafted to another station of the Hansa. Like the guildsmen, they were monopolists ; jealous of their trade secrets and privileges, they bound their members to the strictest celibacy, and forbade them to enter into close business relations with the natives of the country.

At Bruges the Hanseatic merchants numbered about 300 in the days of their greatest prosperity ; there, in the midst of a highly civilized and powerful community, these Germans had to be on their best behaviour. But in the north, where political and economic development was comparatively backward, they gave rein to their Teutonic brutality. At Bergen, the German merchants, more than a thousand in number, tyrannised over the native traders and seamen, and treated their own German recruits with characteristic cruelty.

London's Steelyard

One of the most important counters of the North German Hansa was in London. There, on Thames-side, on the site now occupied by Cannon Street railway station, stood their fortress-depot, called the Steelyard. As elsewhere, dwellings, store-rooms, wharves, and garden were enclosed within a strong wall ; every member went about armed, and at curfew, nine o'clock in the evening, the gates were shut and locked and the keys given into the custody of the master. Communication with the Londoners was kept to the minimum; servants of the Hansa were forbidden to entertain any but Hanseatic members, and were fined if they permitted any native woman to pass the factory gates, or if they fenced or played a game of tennis with an Englishman.

For a long period the Hansa merchants managed to handle virtually the whole trade between England and Germany; until the end of the 16th century they succeeded in excluding English traders from the Baltic. The export duties they paid were lower than those exacted from other aliens, and usually lower than the duties paid by Englishmen themselves ; this privilege resulted from generous loans to impecunious English kings, and it is not surprising that the walls and gates of the Steelyard were sometimes necessary to save its inmates from the fury of the London mob.

From London the Hanseatic men exported wool in huge quantities to Flanders and the

MERCHANT OF THE STEELYARD. The opulence and dignity that characterised the merchant princes of the Hanseatic League are apparent in this portrait of Georg Gisze, merchant of the Steelyard. It was painted by Hans Holbein in 1532.

Kaiser Friedrich Museum, Berlin ; photo, Mansell

WALLS THAT DEFENDED WISBY. Wisby, on the west coast of Gothland, was the centre of Scandinavian trade in the Baltic, and from the 11th century to the 14th enjoyed great prosperity as headquarters of the Gothland association of German traders. The town was fortified at an early period : the existing walls date from the end of the 13th century.

Photo, Dr. F. Stoedtner, Berlin

Rhineland, importing in return Italian and Oriental produce and salted cod-fish. They also did considerable trade with Scotland and Ireland. From Russia they obtained timber, furs and skins, honey, tallow and wax for church candles ; from Sweden came iron and copper, timber, pitch, and granite ; from the Baltic lands grain, from the northern seas herrings. The herring trade was of particular importance during the Middle Ages, when all Europe was Catholic, and when fish was in great demand for eating on fast-days, during Lent, and on Fridays throughout the year. It is significant that the Hanseatic league was chiefly formed of cities of the Baltic, at that time the main area of the herring fisheries. In exchange the Germans imported clothes and silks from Flanders and Italy, beer and wine, trinkets to please half-savage women, and spices from the East to flavour the salt meat eaten in winter.

Hansa Moneylenders

The Hansa merchants also traded in money itself. They were moneylenders, bankers, and currency-manufacturers, and it has been suggested that the term "sterling" became English usage because of the high quality of the coinage of the " Easterlings," as the German merchants were often called. Among the rulers to whom they supplied money was Edward III, who was always in debt by reason of his French wars. For some years the crown jewels were in pawn to the Hansa at Cologne, and it is on record that these merchant princes were granted in return for their loans a lease of some of the Prince of Wales's tin mines in Cornwall.

Decline and Fall of Hansa

For centuries their prosperity continued to increase. Then, for some unknown reason, the herrings ceased to visit the Baltic, remaining in the North Sea to the advantage of English, Scottish, and Dutch fishing fleets ; the change of religion in Germany and England greatly reduced the demand for herrings and wax candles ; the discovery of America and of the sea-route to India left the Hanseatic depots in commercial backwaters ; and the increasing power and wealth of the merchants of even the most backward of the lands in which the counters were established gradually broke the Hansa monopolies. One after another the towns fell away, until in the 17th century only Lübeck, Hamburg, and Bremen remained. The Thirty Years War gave the Hansa its deathblow; the League was dissolved in 1641.

LESSON 14

The Age of the Renaissance

No Hansa arose in Italy, nor was there need of one. Italian towns were not trading outposts in uncivilized and hostile territory, as were many of the Hanseatic counters ; they were inheritors of a tradition reaching back to the days before Rome was an empire. Venice alone reproduced something of the massive dignity and order of the Roman republic. Protected by marshes and lagoons, this city was one of the two Italian powers whose ships carried for centuries the East-West trade of the Levant. The executive government of Venice became vested in a " Council of Ten " ; no other Italian city was ruled with comparable vigour and efficiency.

From Genoa also, at the foot of the Apennines, galleys sailed to every corner of the Mediterranean : caravans of Asiatic traders brought to Venetian or Genoese agents in eastern towns spices from India, pearls from Malabar, precious stones from Ceylon, camphor from Java, gold and ebony from Sumatra. The two cities fought a war lasting nearly a century ; in 1381 Venice emerged the victor.

Near the mouth of the Arno, a hundred miles from Genoa away across the gulf, was Pisa, also her rival and often her enemy. The Pisans concentrated their ships mainly in the western Mediterranean, and for a long period included Corsica and Sardinia within the bounds of their republic. Florence, Pisa's near neighbour, was famous for goldsmiths and merchant bankers, dyers and cloth-finishers, silk-weavers and makers of magnificent brocades. Milan, Verona, Padua, Bologna, Siena, Modena, were also centres of a culture kept alive in the Dark Ages by contact (through Venice and Ravenna) with Constantinople, and no doubt owing something to the short-lived literary and artistic brilliance of the reign of the heretic emperor Frederick II in his kingdom of Naples and Sicily.

These medieval city-states were more or less independent, owing a shadowy allegiance to pope or emperor or even to the French king; in each city the trading aristocracy generally managed gradually to monopolise the government and so establish what was in effect a commercial republic. Sometimes the government was vested in aristocratic consuls, but with the rise of the middle classes a *podesta*, or mayor, was generally appointed as executive. Within the city walls the crowded population included small landed magnates, wealthy merchants, master craftsmen, journeymen, professional men, artists, various grades of secular clergy, monks and nuns, and a crowd of apprentices, servants, and labourers whose life was a matter of struggle and worry and small compensations.

There was a great deal of quarrelling between "old" rich and "new" rich, between impoverished aristocrats and wealthy burghers, landlords and tenants, masters and workers; feuds and riots were frequent. Party passions ran high in and between the cities; loss of power often meant proscriptions, banishments, and executions. Outside the walls there was plenty of danger; cities disagreed with their nominal rulers—bishops, dukes, or counts—over feudal dues and the granting of privileges, and there were arrests and reprisals. Castles of robber barons abounded; traders' convoys were plundered, goods confiscated, merchants held to ransom.

Guelphs and Ghibellines

For two centuries at least the strife of popes and emperors was reflected throughout northern and central Italy by the factions of their supporters, the Guelphs and Ghibellines. These names are said to have arisen at the battle of Weinsberg in Swabia (1140), when Conrad III, Duke of Franconia, emperor, and head of the anti-papal party, used the war-cry *Waiblingen*, the name of his family castle and estate. His opponent, Henry the Lion, Duke of Saxony, used the cry of *Welf*, the Christian name of several of his ancestors, which became the surname of his descendants, the Dukes of Bavaria. In Italy these war-cries were sharpened to *Guelfo* and *Ghibellino*, and grew to be the names of the parties using them.

The Italian cities of the north could unite in face of a common danger. Shaking off the power of their overlords, they came into conflict with the Emperor Frederick I, called Barbarossa because of his red beard. When Ghibelline cardinals elected an anti-pope in defiance of Alexander III, that pontiff allied himself with the cities, whose association became the Lombard League. By 1177 pestilence and military defeat had broken Frederick's power in Italy. By 1198 Innocent III became Pope, and the temporal power of the Papacy rose to its climax.

FASHIONS OF FLORENTINE YOUTH. How the young men of Florence dressed in the second half of the 15th century can be seen from this painting by Domenico Ghirlandaio (1449–94). The youth on the left is garbed in dull blue tunic, black cap, and trunk hose, one leg scarlet and the other white and striped with red below the knee. His companions are dressed in garments of dull blue, green, and scarlet.

The next half-century saw the papacy and the northern French united in bloodily extirpating the Albigensian heresy in Provence and Aquitaine. Innocent claimed supremacy over all crowned heads in Christendom ; the emperor and seven kings—among them John of England and Philip Augustus of France—were compelled in one way or another to accept his interference in their temporal affairs. In 1211 Innocent secured for Frederick's grandson—also a Frederick, and already king of Naples and Sicily—the kingdom of Germany and the imperial title ; in so doing the Pope raised to power the most dangerous enemy encountered by the Church during the Middle Ages.

The Wonder of the World

This enemy, the emperor Frederick II, has already been mentioned in the Lesson on the Crusades, and earlier in the present Lesson as the ruler of a brilliant court whose culture foreshadowed the Renaissance. Far in advance of his age in matters of education and religious tolerance, he neglected his German possessions—leaving them to be run according to feudal custom—in order to concentrate on the establishment of a strong centralised monarchy in his southern dominions. There he broke the power of the nobles and abolished the privileges of the clergy ; he founded the university of Naples and the medical school of Salerno, and welcomed scholars from east and west, Christian or Muslim. Excommunicated for not keeping a promise to go on crusade, he went, and captured Jerusalem, where he was crowned king. By the end of his reign he had the right to wear six crowns ; his contemporaries called him *Stupor Mundi*, the Wonder of the World. He died in 1250, at war with the Lombard League and with rebellious German princes ; as between pope and emperor the struggle was still undecided, but French intervention enabled Pope Urban IV to crush Frederick's heirs and successors in Naples and Sicily.

His family, the Hohenstaufen, was blotted out, the victory of the papacy seemed complete, and the empire never recovered its former power. After a chaotic interval—during which Richard, Duke of Cornwall and brother of the English King Henry III, was elected emperor but never crowned—the imperial dignity was conferred in 1273 on Rudolf of Hapsburg. It became hereditary in the Hapsburg family in 1438, from which time Hapsburgs ruled as Holy Roman Emperors until 1806, and as emperors of Austria until 1919 ; but between 1250 and 1806 only five emperors were crowned by a pope, and Rudolf himself was not one of them.

DANTE ALIGHIERI (1265-1321). One of the world's greatest poets, he became involved in the party conflicts of his age and was banished from Florence. This portrait mask is in the Uffizi Gallery, Florence.

The French States-General

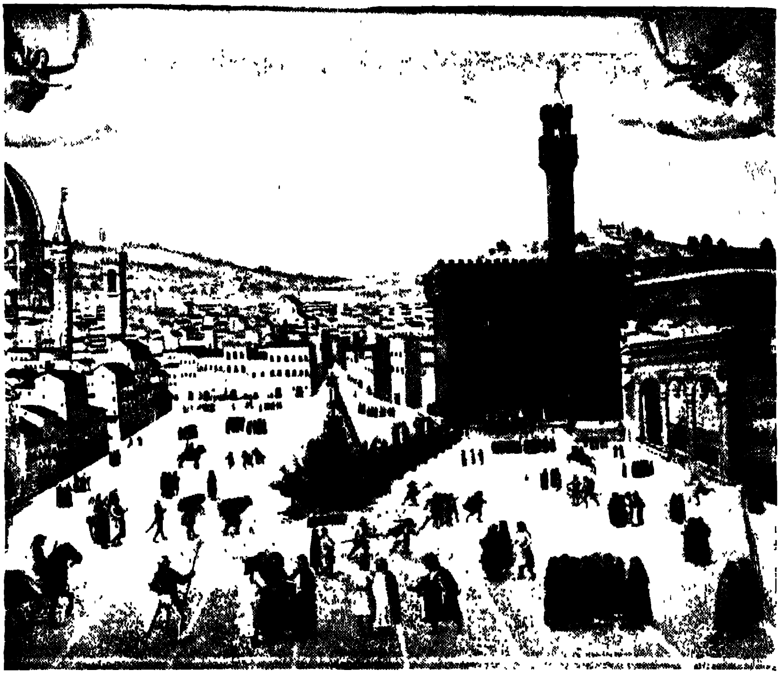
The papacy had defeated one powerful enemy only by summoning help from a power which presently proved even more dangerous : the power of the French monarchy. Philip IV of France quarrelled with Pope Boniface VIII, not over doctrine but over his taxation of the clergy and his claim to try in a French court a bishop accused of plotting against him. During the struggle Philip summoned for the first time the French states-general—clergy, nobles, and commons, in one body, a portent in the history of France and of Europe. Boniface excommunicated Philip ; the king's agents in Rome joined the pope's personal enemies and threatened the aged Boniface with physical violence.

Council of Constance

This outrage made a profound sensation throughout Europe ; Dante said that Christ had been mocked again in the person of his vicar. Boniface and a successor died in rapid succession ; Clement Bishop of Bordeaux became pope as Clement V, and by previous arrangement with Philip freed him from excommunication and went to live in the papal city of Avignon, surrounded by French territory and plainly in the power of the French king. Thus (in 1305) began the famous " Babylonish Captivity of the Church," which considerably lessened the prestige and spiritual authority of the papacy. In 1377 Pope Gregory returned to Rome, but on his death in the following year the cardinals split into factions, and two popes were elected, one at Avignon, the other at Rome. This division, called the Great Schism, lasted till 1417. The Council of Constance closed the schism and secured the elevation of Pope Martin V.

This council declared the superiority of such councils over the pope. It also violated the safe-conduct given to the Bohemian John Huss, summoned on the charge of preaching heretical doctrines (similar to those held by Wycliffe in England) ; Huss was burnt, but his followers were crushed only with great difficulty, and the prestige of the papacy declined further towards the point, still a century away, when the Reformation would cut half Europe from under it.

Meanwhile the Turks were pressing hard upon the Greek empire, which was at last restricted



THE EXECUTION OF SAVONAROLA. On May 23, 1498, Girolamo Savonarola, the reforming prior of San Marco, was executed with two companions in the Piazza della Signoria at Florence. The scene is depicted in this almost contemporary painting by an unknown Florentine artist. On the right is the Loggia de' Lanzi, and beyond is the massive Palazzo Vecchio, from 1298 to 1532 the seat of the Florentine government. On the left is a portion of the Duomo.

Mu di San Marco, Florence, photo, Alinari

to Constantinople and a shrinking area close around the city. An attempt was made to unite the Churches of East and West, but agreement in 1452 came too late to restore any sense of common danger or political unity. The city was stormed in 1453; the "Roman" empire of the East came to an heroic end, and fragments of the libraries and learning of Constantinople were scattered westwards over Europe.

Dante's Work

These, briefly, were some of the events preceding, accompanying, and shaping the advent of the Italian Renaissance. The name of Dante has already been mentioned. The 13th century was the age of the "Schoolmen" mentioned in Lesson 10, but the culture of the time is best displayed in Dante's own work. This profoundly gifted Florentine, the first classical poet of modern Europe, was a Ghibelline, a man of affairs exiled for many years from his native city.

His *Divina Commedia* embraces much of the highest thought and aspiration of the Middle Ages; its form is medieval, but its language is Italian, not Latin, and its spirit is for all time. An allegory of human existence is presented as a vision in which Dante is led by Virgil (representing philosophy based on reason) through Hell and Purgatory to Paradise, where Beatrice (representing wisdom divinely revealed to man) takes on the office of guide and conducts him to an experience of eternity. Beatrice was the girl, long dead when Dante completed the poem, who inspired him with an ideal, mystical, lifelong love beyond comparison in literature.

Other Famous Florentines

Dante's dates were 1265 to 1321. Villani (c. 1275–1348) wrote the first history in Italian. The poet Petrarch (1304–74) and the prose-writer Boccaccio (1313–75), the first humanists of international repute, both knew some Greek, as Dante did not; Greek began to be taught in Italy only at the end of the 14th century. From that time onwards Greek literature and philosophy captured the cultured Italian mind. Of the pictorial artists who broke away from Byzantine tradition, Giotto (1266–1337) was the greatest and most successful. All these men were Florentines, but the new learning spread in every direction. At the universities of Padua, Bologna, and Salerno chairs of rhetoric were founded; their holders dealt heroically with the whole body of classical history, literature, philosophy, science, and law.

Artistic Construction and Decoration

Other cities established universities or academies in which travelling scholars lectured for a while before being attracted elsewhere by a higher fee offered by another ruling house or magistracy jealous for the credit of its own educational organization. Long before the fall of Constantinople, secular and humanistic studies were altering the Italian upper and middle classes to something much more civilized than the bulk of their social equals elsewhere in Europe.

Schools of painting and sculpture arose at Florence, Venice, Milan, Padua, and elsewhere;

ruins of Roman buildings contributed ideas to the great works of the Renaissance architects, of whom Brunelleschi (1379–1446) was the prime reviver of classical forms. Popes, cardinals, nobles, and merchant princes collected antiques and manuscripts, and paid for the decoration of churches and palaces. The leading artists and architects employed large numbers of assistants; skilled and literate craftsmen of many kinds formed a new class in the community, being concerned with artistic construction and decoration no longer confined to religious uses.

Lorenzo the Magnificent

The cities took to employing mercenaries to fight their wars for them; these *condottieri* developed a technique of treachery and shadow-fighting which came to a startling end when in 1494 the French under Charles VIII invaded Italy. Then began a new epoch of savage warfare between French, Germans, and Spaniards all over the peninsula and in Sicily. In 1527 a mixed imperial army sacked Rome. A by-product of these wars was the spread of loot, of classical learning, and of the Renaissance spirit into the neighbouring western and northern countries of Europe.

The papal throne was occupied by a succession of Renaissance churchmen, but the peak of the High Renaissance was reached at Florence during the governance (1469–92) of Lorenzo de' Medici, called "the Magnificent." This descendant of merchants was just to his subjects, magnanimous to his enemies, a generous rewarder of excellence in literature and the arts, a founder of schools and libraries, and a man of profound understanding. Among the artists whose patron he became were two young men whose names were destined to crown the age in which they lived: Leonardo da Vinci (1452–1519) and Michelangelo (1475–1564).

Two years after Lorenzo's death the French entered Florence, and the Medici fled. Savonarola (1452–98), prior of the Florentine monastery of San Marco, had preached for years against the pagan spirit of the city and the age; to his followers the coming of the French was a fulfilment of his prophecies of downfall of the régime and an opportunity for the suppression of vice and frivolity. Savonarola gained the support of the populace; a fury of contrition swept across the city, and was expressed by a 60-foot-high bonfire of "vanities" – playing-cards, dice, carnival costumes, jewels and ornaments, lewd books and pictures—which roared up in promise of a change of heart, which lasted a very short while.

Savonarola the Heretic

By a grim irony this high-minded reformer and orthodox churchman was prohibited from preaching by Pope Alexander VI, possibly the most infamous holder of the office of sovereign pontiff. Savonarola refused to obey. He was tried on a charge of heresy, and strangled (or hanged) with two companions in the market-place of Florence. Before being burnt the three bodies were treated with savage buffoonery by the hangman; the mob which had howled approval of the execution was suddenly sickened by this behaviour, and pelted him with stones. Seldom can a mob have enjoyed such a mob-satisfying occasion.

Shortly afterwards the Medici returned to power in the city. Lorenzo's son, Giovanni, became Leo X, Pope from 1513–21, who

BOOK PRODUCTION IN THE 16th CENTURY. These woodcuts by Jost Amman, a Swiss or German engraver who lived 1539–91, show the production of a book in the century immediately following that in which printing was invented. On the left, paper-making with a pulping mill and a press in the background. Centre, printing from a wooden hand press. Right, bookbinding, with one workman threading the sheets at a frame in the background and another trimming them up in the press.

From Jost Amman, "Stände und Handwerker"

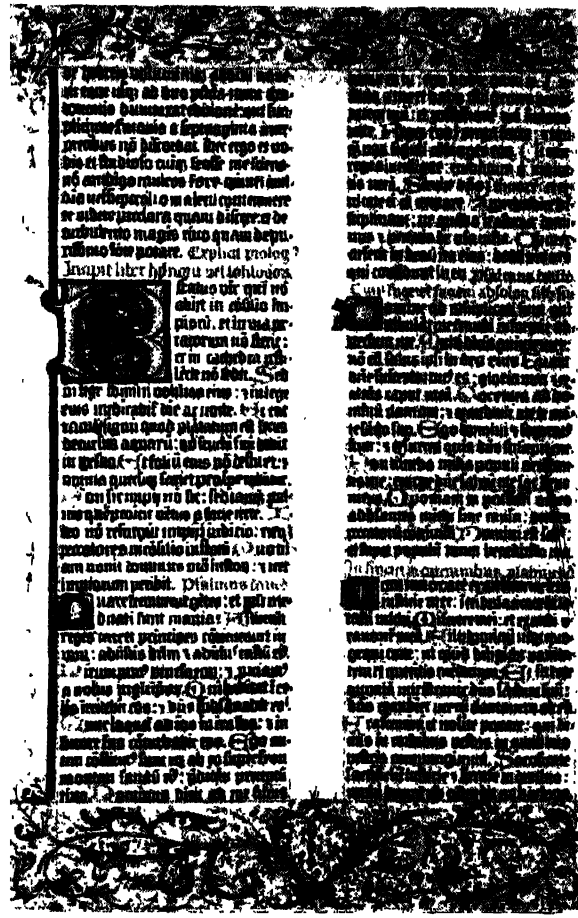
poured out the papal revenues to support art and letters and music. His famous bull granting indulgences to all who should contribute to the building of the new church of St. Peter's in Rome was a contributory cause of the crisis which now arose in Christendom, for against the sale of those indulgences Martin Luther (1483 1546) made his stand. In 1521 the Imperial Diet of Worms declared Luther a heretic. The Age of the Renaissance passed into the Age of the Reformation.

The spread of Greek learning and the consequent revival of classical ideals and philosophy had, however, marked only the first phase of the great humanist movement, which might have run most of its course in scholars' studies and in the halls of universities and academies. It spread to all ranks of society because of a mechanical invention—the printing press—which had more influence on history than any other that the world has so far seen.

The Printing Art

The place and manner of origin of the first printing press are not certainly known. The printing art is believed to have been practised in China in the 10th century, and printing from movable types as early as the 12th or 13th century; but printing was not practised in Europe until the 15th century. Some bibliographers claim that the inventor, so far as Europe was concerned, was a Dutchman, Laurens Janszoon Coster (*c.* 1370–1440), of Haarlem, who experimented for some years and made the great discovery some time between 1420 and 1426. Others assert that the invention should be ascribed to a German, Johann Gutenberg (*c.* 1400–68), of Mainz. Certainly Gutenberg's name appears in connexion with the first piece of printing that can be definitely dated—an indulgence granted by Pope Nicholas V to those who should contribute towards the expenses of a war against the Turks. This was printed at Mainz in 1454, and, it is believed, was produced by Gutenberg in association with Johann Fust, a goldsmith and money-lender, and Peter Schöffer.

Gutenberg is also believed to have had a very large part in the production of the first printed Bible, variously called the Gutenberg, the 42-line (from the fact that it had 42 lines to a page), and the Mazarin bible (a copy of it having been found in the library of Cardinal Mazarin). This Bible probably appeared in 1455, and about two years later it was followed by a psalter. About 1466 the partnership of the three pioneers seems to have been dissolved: Gutenberg became a pensioner of the archbishop of Mainz; Schöffer, with or without the aid of Fust, continued as printer in charge of a press until the beginning of the next century.



PAGE FROM THE FIRST PRINTED BIBLE, variously called the Gutenberg and the Mazarin bible. It was the first book printed with movable type, and it appeared probably in 1455. The illumination of the initials and borders was done by hand.

The new art spread with great rapidity to other lands, helped perhaps by the sack of Mainz in 1462, which dislocated the city's life for a time and led to the migration of its most enterprising workmen. Printers were at work beyond the Alps in 1465 and beyond the Pyrenees in 1474; the printing press reached England in 1477, Denmark in 1482, Sweden in 1483.

The man who brought it to England was William Caxton, of immortal memory. Born in Kent about 1422, he was apprenticed to a mercer in London and then set up business in Bruges; there or at Cologne he became interested

If it plese ony man spirituel or temporel to bye ony pyes of two and thre comemoracio̅s of salisburi vse enpryntid after the forme of this prese̅t lettre whiche ben wel and truly correct, late hym come to westmonester in to the almonesrye at the reed pale and he shal haue them good chepe .·.

CAXTON'S ADVERTISEMENT, issued from the sign of the Red Pale in the Westminster Almonry. William Caxton (c. 1422-91) emigrated to Bruges in 1441, and set up his first press there. On his return to England in 1476 he introduced printing to his native country.

in printing. At Bruges he set up his first press ; in 1474 he produced the *Recuyell of the Historyes of Troye,* the first book printed in English. He had abandoned commerce and entered the service of the Duchess of Burgundy, sister of Edward IV ; when she returned to England, he followed her, and apparently towards the end of 1476 opened his famous printing press at the sign of the Red Pale in the Almonry, close to Westminster Abbey. The first book printed in England was Earl Rivers's translation from the French, *Dictes or Sayengis of the Philosophres,* which Caxton issued in November, 1477. before his death in 1491 he printed about a hundred works, comprising some 18,000 copies. Many of the books were translations, and Caxton's own renderings into English amounted to more than 4,500 printed pages. After his death the press at Westminster was conducted by his principal assistant, Wynkyn de Worde, who by 1502 was established in Fleet Street —a printer at the sign of the Sun—the first connexion of that locality with the printing trade.

LESSON 15

Discovery of the New World

It has often been contended that the Turkish conquests cut the trade routes between the East and Europe, and so provoked the eastward voyages of the great Portuguese sea-captains. Actually those voyages were the outcome of a series of efforts begun long before the Turks captured Constantinople (1453) and overran Egypt (1517).

From 1418, annual expeditions, organized by Prince Henry "the Navigator," left Lisbon with the aim of finding a sea route to Abyssinia and perhaps to India. This prince was a son of John I of Portugal and John's queen Philippa, daughter of John of Gaunt and sister of Henry IV of England ; he set himself to direct sea trade and discovery, with an underlying or additional crusading motive. Before 1420 his ships had rediscovered Madeira, lost to European knowledge since the fall of the Western Roman Empire. The Azores and Canary islands were made into Portuguese colonies ; Prince Henry's large caravels explored farther and farther along the African coast, bringing home cargoes of gold, ivory, spices, and slaves.

PRINCE HENRY "the Navigator" devoted his immense wealth to maritime exploration.

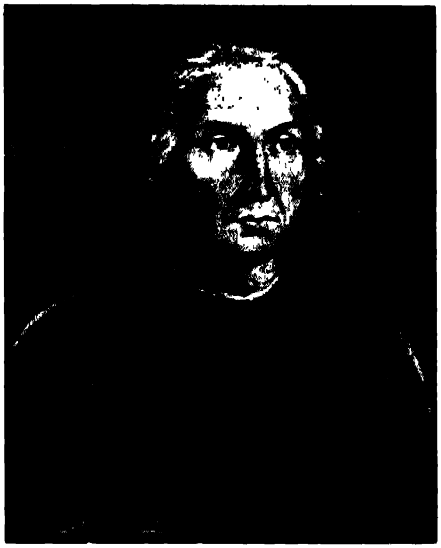
By 1460, when Prince Henry died, they had sailed up the Gambia river. In 1486 Bartolomeo Diaz rounded the promontory he called the Cape of Storms. Those storms so frightened his crew that they compelled him to turn back at once, and when they returned to Portugal the king, John II, decreed that the ominous name must be changed to the Cape of Good Hope. In 1497 Vasco da Gama set out on the first sea voyage to be completed between Portugal and India. He reached Calicut on the Malabar coast, the principal centre of the "Moorish" trade with India, and had difficulty in escaping from the harbour, although a local ruler had been friendly. Da Gama reached the Tagus again in 1499 ; the Portuguese at once decided to divert trade to the Cape route. Fleets were despatched regularly, and in 1503 pepper was selling in Lisbon at a fifth of its price in Venice.

The Portuguese then set out to gain naval supremacy in the Indian Ocean. In 1509 Almeida crushed combined Indian and Egyptian fleets in a battle of Diu (the south point of the Kathiawar peninsula). Albuquerque had already captured Socotra, commanding the Red Sea entrance, and Ormuz at the mouth of the Persian

VASCO DA GAMA, discoverer of the ocean highway to the East.

Gulf; in 1511 he took Malacca in the Malay peninsula. Thenceforward until the Suez Canal was opened in 1869, the Cape route carried the great bulk of trade with India and the Far East.

In 1492, five years before da Gama's departure on his epoch-making eastward voyage, Cristobal Colon (1451–1506), whose name is rendered in English as Christopher Columbus, made his famous first crossing of the Atlantic; sailing from Palos in south-western Spain in the *Santa Maria* (100 tons), accompanied by two smaller vessels, he landed on the island of the Bahamas group which he named San Salvador, now called Watling Island.



COLUMBUS. Painted by the Venetian artist Lorenzo Lotto, this is reputed the best portrait of Christopher Columbus. On October 12, 1492, Columbus set foot on the Bahamas and opened a new volume of world history.
Musée du Marine, Madrid, photo, Laurent

Columbus was born in Genoa, probably of a Spanish-Jewish refugee family, and his early years as a sailor took him to England, Ireland, and possibly Iceland. His belief in land far to the westward was less remarkable than the energy which eventually overcame all obstacles in the way of obtaining support for his expedition from Ferdinand and Isabella, joint Spanish sovereigns, whose armies had captured Granada from the Moors in that same year. Columbus was confident that he could reach the Indies by sailing round the globe; he carried a royal letter of introduction to the grand khan of Cathay (to whose ancestors Marco Polo and others had made themselves known by overland travel in the 13th and early 14th centuries), and he believed to his death he had reached the eastern confines of "India."

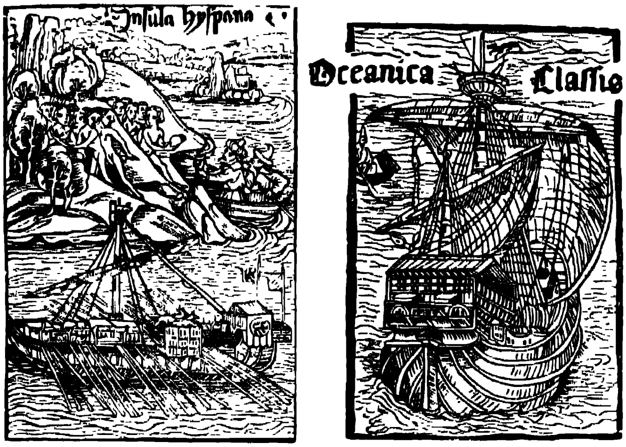
Columbus, Admiral of the Indies

He explored among the islands now called the West Indies, and on the second of these subsequent voyages reached Trinidad and coasted along the mainland as far as the mouth of the Orinoco. A skilful and dauntless explorer and sea-captain, Columbus was no general or administrator; his first settlement was a dismal failure, and later efforts brought upon him temporary disgrace and a voyage home in irons. He died in Spain in 1506, still Admiral of the Indies (which title remains with his descendants) but long replaced as viceroy of the growing Spanish dominions in America.

Nothing is known of the relation (if any) to Columbus and his voyages of the independent discovery of the North American continent by John Cabot (1450–98) in the *Matthew*, 1497. The two explorers may have met; Cabot was probably Genoese by birth, but he had become a naturalised citizen of Venice when he was a merchant or factor engaged in the spice trade by the ancient land route across Arabia. At all events Cabot visited Mecca and understood the method of successive exchanges by which spices came from the East. He, too, wanted to reach the eastern part of Asia, and made efforts to interest authorities at Lisbon and Seville. About 1490 he arrived in England. Henry VII gave him a patent to sail under the English flag to all coasts of the eastern, western, and northern seas; the omission of "southern" suggests that Cabot was not authorised to follow the course of Spanish and Portuguese discoveries.

He set sail from Bristol, and after a voyage of four and a half weeks sighted land, no doubt what is now either Newfoundland or Nova Scotia. A long southward coastwise voyage convinced him that he had found the mainland of Asia. He observed signs that the land was inhabited, but saw no people, let alone the populous cities of Cathay visited by Marco Polo (*c.* 1254–1324) two centuries before. Naturally not wishing to encounter possible enemies in overwhelming force, he returned to Bristol with his information. It included news of the cod to be caught on the Newfoundland Banks, which became a permanent fishery for English seamen. Of his second voyage, with four ships, nothing definite is known; it may have ended in disaster.

In 1499 a Portuguese named Corte Real rediscovered Greenland, where a colony founded by medieval Norsemen had lately died out. Another Portuguese, Fernandez, a minor landowner of the rank called "llabrador," informed Henry VII of England of this achievement; Greenland was then called by the English "the land of the llabrador," Terra de Llabrador, which name was later transferred to its present locality in North America. Other Portuguese, and Fernandez himself in association with several British merchants, appear to have made the



DISCOVERY OF THE WEST INDIES. To Christopher Columbus himself is attributed the drawing of the ship on the right, the ship in which he discovered the island of Hispaniola (San Domingo) in 1492. The woodcut, left, depicts his landing, and is an illustration to a pamphlet published in Basle, 1494, describing "the islands lately discovered in the Indian Sea."

first attempt to find a north-west passage to Cathay round this obstacle, the New World. Henry VII, in commissioning these men, evolved the doctrine of "effective occupation" which was constantly evoked in later Tudor and Stuart times when the English colonial empire was in process of foundation.

In 1509 John Cabot's son Sebastian attempted the north-west passage, and was turned back by mutiny and floating ice. There is little doubt that he had anticipated Henry Hudson (died 1611) by discovering Hudson's Bay. On his return to England he found Henry VIII uninterested in western exploration. So he entered the Spanish service, commanded an unprofitable expedition to South America, and afterwards returned to England, where he became governor of the Merchant Adventurers, and organized their Russian trading voyages in 1553 and later years.

After the discoveries came settlements, conquests, and savage exploitation. In his description of the islands he discovered Columbus remarked on the wonderful vegetation, as green as that of Andalusia in April ; on the flocks of parrots that darkened the sun, large and small birds of many other different kinds, splendid trees, and scented fruits. The people lived in houses like tents, very high, with good chimneys ; and they were so unsophisticated that they thought the rough, fair-skinned mariners were gods come down from the sky. Columbus observed that they had no religious creed :

> They are very gentle and do not know what it is to be wicked, or to kill others, or to steal, and are unwarlike and so timorous that a hundred of them would run from one of our people.

Their only fault, apparently, was their unabashed nakedness.

Then come words from Columbus which were to bring death and disaster to many thousands of Indians :

> They are very ready to repeat any prayer that we say to them, and they make the sign of the cross. So your highnesses should resolve to make them Christians, for I believe that, if you begin, in a little while you will achieve the conversion to our holy faith of a great number of peoples, with the acquisition of great lordships and riches and all their inhabitants for Spain. For without doubt there is in these lands a very great amount of gold . . also jewels, valuable pearls and an infinite amount of spices.

This double appeal, to fanaticism and greed, was speedily answered. Across the Atlantic streamed the caravels and galleons with their cargoes of determined friar-preachers and brutal soldiers. Cortes conquered the Aztecs of Mexico, 1519–21 ; Pizarro overthrew the Incas of Peru, 1533. Both these captains won their first victories with fantastically small forces of Spanish veterans, whose body-armour, firearms, and horses terrified the Indian peoples. Here and there the natives fought with the fury of despair, but within a few decades the New World of Central and South America had passed under the dominion of Spain or Portugal. The Indians of the Brazilian coast (discovered in 1500) were too feeble to do the work their European masters demanded of them, so the Portuguese imported Negro slaves from Africa, thereby beginning a process that has bedevilled the whole subsequent history of the continent. The gold and gems of the west poured into Europe, immensely aggrandising the power of Spain, in which country the Catholic Church was to find its champion during the ferocious religious wars of the 16th and 17th centuries.

Peasant Life Goes On

Other effects of the discovery of the New World on European countries with Atlantic seaboards were increases in shipbuilding and seafaring, in naval and mercantile rivalry, in slave traffic, in piracy, in knowledge and speculation among geographers, and in wealth among merchants and soldiers of fortune—wealth they did not allow their sovereigns or governments to claim entire. The early Spanish, Portuguese, and English adventurers were speedily followed by rivals from France and the Netherlands ; the quarrels of Europe began to be echoed in American coastlands from Newfoundland to Brazil, and then to resound in the council chambers of the Old World.

Meanwhile in every European country peasant life went on as before. Peasants raised crops, pastured flocks and herds, cut down trees, cleared waste land, fished in rivers and gulfs,

and lived with their pigs and poultry. Mining, metal-working, quarrying, building with stone, roofing with tiles, and many textile and other industries and crafts, with every kind of town trading, all continued to develop and to draw an increasing proportion of the population away from the agricultural labour on which their food depended and still depends. A long time was to pass before America became a land of promise to the European labourer.

An obscure sequence of events had led to the naming of the "new" continent after one Amerigo, surnamed Vespucci (1451–1512). Born at Florence, this merchant adventurer began his career as a clerk in the great commercial house of the Medici, probably became one of their agents in Spain, and subsequently made several voyages to the west, concerning which his own accounts differed. He took Spanish nationality, and in 1508 was appointed "chief pilot" of Spain. In 1503, in a letter (now lost) written in Italian to one of the Medici, Vespucci claimed to have reached the western mainland in 1497 (on a date eight days before it was reached by John Cabot); a Latin translation of a French version of this letter was printed in the *Introduction to Cosmography* published at the University of St. Dié in Lorraine in 1507, in which work also appeared a suggestion that the new part of the world should be called America because "Americus" discovered it. The temporary disgrace of Columbus may have contributed to the popularisation of the suggestion, and so to one of the most striking oddities of historical nomenclature. Vespucci's 1497 voyage is now frequently discredited.

LESSON 16

Scientists and Reformers

In Lesson 10 Roger Bacon was described as the most original thinker of the Middle Ages. His service to science was double; he formulated principles of inquiry, but he also made discoveries himself, chiefly in physics. Some of these findings he may have taken over from the writings of Arabian philosophers, but thanks to him and to other pioneers, the 12th and 13th centuries produced in Europe the compass, gunpowder, spectacle lenses, mechanical clocks, new means and methods of dyeing textiles, and other devices by which men increased their knowledge of, and power over, their physical environment, and facilitated the spate of discovery and invention in the 15th and 16th centuries. The invention of printing expedited the exchange of ideas.

Vasco da Gama (*c.* 1460–1524) brought back from his first great voyage round Africa not only information about India but also evidence in his ship's log of the spherical nature of the earth's surface. He had recorded the shift of the known constellations, the rise of new stars as he journeyed southwards. In 1519 another Portuguese, Magellan (*c.* 1480–1521) set out to circumnavigate the world. He sailed through the straits later called after himself, and crossed and named the Pacific Ocean. Magellan was murdered in the Philippine Islands, and one of his lieutenants brought the ship home by way of the Cape of Good Hope, thus proving the truth that astronomers had deduced long before, that the earth is a globe.

From the time of the geographer Ptolemy (2nd century A.D.) his supposition that the earth was the centre of a mobile universe had been accepted without serious question. In 1473 was born Copernicus, one of the foremost figures of the Renaissance, whose career illustrates both intellectual and physical movements of the New Learning. Son of a merchant of Thorn in Poland, he was educated under the care of his uncle, a bishop; his university studies included mathematics and optics at Cracow, canon law at Bologna, and medicine at Padua. In 1497 he became a canon at Frauenberg in East Prussia, and in 1500 he was appointed a lecturer in astronomy in the university of Rome. Retiring to Prussia, he was made administrator-general of his uncle's diocese of Ermeland. There, while Reformation and Peasants' Revolt flared through Germany, Copernicus wrote or completed his book *De Revolutionibus Orbium Celestium.*

Founder of Modern Astronomy

In this work he established that the earth was not the centre of the universe, that the apparent movement of the heavenly bodies resulted from the earth's own rotation, and that there was no "celestial sphere" in which the stars hung equidistant from the earth. He also explained the apparent retrograde movement of Mars, and the principle which governed that movement and was extensible to the movement of other planets. Disliking argument, indifferent to fame, and realizing that theologians would quarrel with his findings, Copernicus eventually allowed friends to persuade him to let his work be printed. A cardinal paid for the printing, and the book was dedicated to Pope Paul III. Copernicus died on the day of its publication in 1543, unable to do more than touch the volume with his hand. But in it he had laid the foundation of modern astronomy.

His apprehension was not misplaced, yet it was the Reformers who first denounced his work and demanded its suppression. The

Catholics, perhaps disarmed by the dedication, did not put this classic on their index of forbidden books until many years later. Within the lifetime of Copernicus (1473–1543), or just before or after it, fell a dozen or more dates of the utmost importance to the European continent and to the modern world ; some of them have already been mentioned, but they will bear repetition as key events in social history, although their implications at the time of happening may have appeared almost entirely religious, political, or military.

Italy's First Printing Press

In 1471 the first printing press was set up in Italy. The treasures of Greek and Latin literature unearthed from monastic libraries began to spread in all directions. In 1476 the army of townsmen and peasants of the league of Swiss cantons, which for two hundred years had defended its self-governing societies in the mountains, broke the might of Burgundy, the last real medieval power in western Europe. Charles, Duke of Burgundy, called "Le Téméraire" (often translated "the Bold" but better rendered as "the Rash") was killed, and his army shattered, near Nancy in Lorraine. The Swiss confederation included various forms of government, and the toleration evolved between and among the cantons enabled the reformers Zwingli (1484–1531) at Zurich, and Calvin (1509–64) at Geneva, to formulate and preach their beliefs without at first colliding with the temporal power of the papacy. A by-product of the Swiss victory was the subsequent hiring-out of the formidable Swiss infantry during the ensuing wars, and their provision of bodyguards for the French kings and the popes. The Swiss papal guards still wear a uniform designed by Michelangelo.

Erasmus of Rotterdam

The voyage of Columbus in 1492, and the French invasion of Italy in 1494, began from outside and inside Europe a new period of the history of the continent. In 1507 died Caesar Borgia, soldier son of Pope Alexander VI, and pattern of the ruler who separates political science from ethics, as described by Machiavelli (1469–1527) in his book *The Prince* ; and in a world of rulers not unlike him Switzerland again sounded a different note.

In 1501 the city of Basle or Basel had joined the Swiss Confederation. In 1516 it was the place of publication of an edition of the Greek New Testament, cleared of many obscurities and accompanied by editorial notes together with a new translation of the text into Latin. The editor and translator was the great Erasmus of Rotterdam (1466–1536). A few years older than Copernicus, this Dutch scholar perhaps shares with the Polish astronomer the main responsibility of leading Europe to its shaking-off of the Middle Ages. A canon of Steyn, near Gouda, Erasmus almost personified the literary side of the Renaissance in northern Europe. A voluminous author and letter-writer, he met many of the leading men of the age, and spent periods at the universities of Louvain, Paris, Turin, Oxford, Cambridge, and Basle.

He was the pioneer of Biblical criticism, and an upright, humane, and humorous man, who seemed unable to understand how his labours provoked and inflamed the doctrinal quarrels of the mystics and fanatics of the period. Tolerant, appealing to reason, too honest to restrain his pen, too timid or fair-minded for heroism, he shrank from extremes and was blamed by extremists. He remained unaware of the stirrings of new science or philosophy or political economy, but his contributions to social conscience and to morality in public affairs persist in spite of the power politics so ably described by Machiavelli.

Luther's 95 Theses

In 1515 the Italian wars took a new turn ; Francis I of France, allied with the Venetians, heavily defeated a joint papal and imperial army (including Swiss mercenaries) at Marignano ; the military power of the Empire was thus prevented from being turned against the Reformation in time to crush it.

In 1517 the monk Martin Luther (1483–1546), then professor of theology at the new university of Wittenberg in Saxony, nailed up on the door of the castle church there his 95 theses directed against ecclesiastical abuse of the complicated doctrine of indulgences—a doctrine widely interpreted as permitting pardon for sins to be bought for money. This act began the Reformation in Germany. Three years later Luther burned the papal bull condemning his doctrines ; he was protected by the Elector of Saxony, and reformed teaching continued to spread through various countries of Germany. It was partly borne on a tide of nationalistic feeling, but contained much sincere protest against Catholic ideas and observances.

Leonardo da Vinci

Meanwhile, in 1519, one of the outstanding creative geniuses not only of the Renaissance but of all time had died as an honoured guest of Francis I near Amboise on the Loire. Born in 1452, Leonardo da Vinci was the illegitimate son of an Italian notary and a woman sometimes described as a lady, sometimes as a peasant. Of formidable intellect and remarkable personal strength and beauty, he became painter, sculptor, poet, composer, scientist, architect, engineer, and philosopher. The tale of his achievements is itself a wonder of the

world. The man who could paint "The Last Supper," "The Mona Lisa," and "The Virgin of the Rocks" could also fashion a silver lute in the shape of a horse's head, design a court masque, write an astonishing fictional account of a journey in the Near East, and dissect animals and insects to provide a convincing build-up for the anatomy of a heraldic dragon. He could plan tunnels, water-works, and canals (he was for a while Caesar Borgia's chief engineer); he invented types of water-mill and breech-loading cannon, a mincing-machine, a paddle-wheel for boats, and a submarine—the design of which he destroyed because he thought men would misuse such a device.

Many-sidedness of Social Life

He made inquiries and researches into the composition of explosives, the motive power of steam, magnetic attraction, the use of a stone-saw, and the circulation of the blood. He discovered laws of optics, gravitation, friction, heat, and light, and may have forestalled Copernicus in evolving the theory of the earth's movement. He certainly forestalled the French zoologist Lamarck (1744–1829) in classification of animals into vertebrates and invertebrates; and he gave much time to the problem of flying-machines. His manuscript notebooks, crowded with drawings, remain among the most remarkable documents of history; as an all-round man he will probably never be surpassed, specialisation having so much deepened and developed since his day that no one brain could cope with even the theory of such a range of subjects.

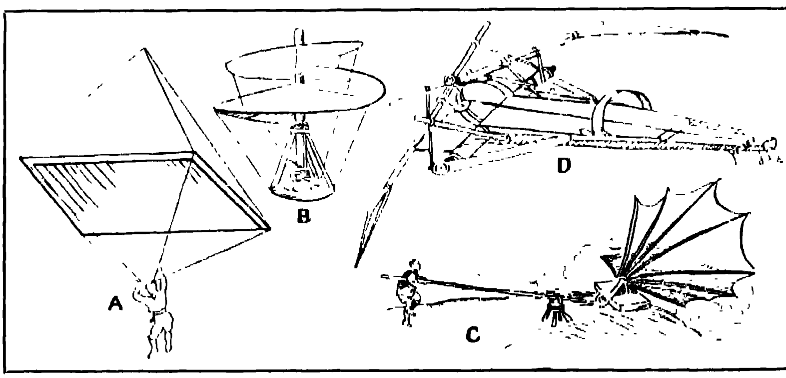
The list of Leonardo's main interests illustrates the many-sidedness of social life and educated thought in the later Italian Renaissance. Economically he, like all his great artist peers—Michelangelo, Raphael, Titian, and the rest—was dependent on the patronage of pope, king, cardinal, prince, or doge; for peace, and time to work in, he had to dodge their wars and sacking of cities, and for reward he sometimes had the scrapings of treasure-chests which had been emptied to pay the soldiery. The very existence of such an individual reveals how far the power of thought had carried the vanguard of humanity at the beginning of the 16th century.

In 1519, the year of Leonardo's death, Charles V, king of Spain, Sicily, and Sardinia, succeeded his grandfather Maximilian as emperor, and inherited from him the rule of the Netherlands (Maximilian had married the daughter and heiress of Charles the Rash). Charles V was also king of the new Spanish dominions in America. He inherited, too, the struggle with France; and in 1524 some of the German states were shaken by the terrible peasant rebellion. Luther's doctrines had played a part in unsettling the wretched peasants, and Luther's pamphlet urging the governing class to stamp them into submission remains a reproach to his memory. In 1525 the rebellion was at an end. In the same year an imperial army defeated and captured Francis I at Pavia. A quarrel with the pope prevented the emperor from dispensing with the support of the Protestant princes.

Cellini and Rabelais

One of these princes was Albert of Brandenburg, grand master of the order of Teutonic Knights which had conquered East Prussia from the Lithuanian heathen. In 1526 Albert made the lands of the Order into an independent duchy; at that time this obscure Baltic province was the home of Copernicus. It was destined to grow into the kingdom of Prussia, the matrix of the German dream of dominion which has brought repeated disaster on Europe and the world.

In 1527 Pope Clement VII took refuge in his castle of St. Angelo (built on the remains of the



LEONARDO DA VINCI AS A PIONEER OF AVIATION. MSS. left by Leonardo da Vinci (1452–1519) reveal the great Renaissance artist as the first pioneer of the science of flight. Above are reproduced four aeronautical sketches from his note-books. A shows a parachute of calked linen. B affords ground for including the helicopter among da Vinci's numerous discoveries; the machine consists of a helical wheel set in motion by the release of a twisted spring, so that "the said helix is able to make a screw in the air and climb high." C represents a man operating a mechanical wing. D is a complete flying machine consisting of a plank on which lay the aviator, and two "oars" or wings operated by the feet by means of stirrups fixed at the rear.

After drawings by Leonardo da Vinci

mausoleum of Hadrian) while the imperial troops stormed and plundered Rome, not sparing the Vatican or St. Peter's. In the papal garrison was Benvenuto Cellini (1500–71), Renaissance goldsmith and autobiographer, whose claim to have shot with his arquebus the enemy commander (the Constable Bourbon, a French renegade) has never been proved.

In 1529 Lutheranism was officially established in Sweden. In the same year the Turks besieged Vienna for two months; civil war in Germany was averted by this outside danger, which three years later was still sufficient to compel Charles V to agree to the religious peace of Nuremberg. In 1533 Henry VIII of England broke with the pope.

In the same year the Frenchman Rabelais (1483–1553), humanist, ex-monk, and physician, published *Gargantua*, the first of his tremendously vigorous satires on the social and religious life of the time. His particular butt was dogmatic tyranny, whether of Catholic or Calvinist; the rambling burlesque form of his writings prevented their revolutionary trend from becoming so apparent while he lived as to cause Rabelais serious trouble.

In 1535 Henry VIII assumed the title of Supreme Head of the Church of England. In 1538 an English Bible was placed in every English church, and in the following year Henry completed the dissolution of the English monasteries; this move resulted in the enrichment of a new aristocracy (as the price of their support for Henry's ecclesiastical policy), the disappearance of any means of relief of the very poor, and the consequent aggravation of social misery and violence. By 1541 the French reformer John Calvin (1509–64) was supreme at Geneva, and the three great branches of Protestant belief—Lutheran, Anglican, and Calvinist—were firmly set on their separate paths leading away from Rome.

LESSON 17

Scientists and Witches

Before the middle of the 16th century the "Counter-Reformation" was launched; the great "Company of Jesus" or Jesuit Order, founded by a Spanish nobleman and ex-soldier, Ignatius Loyola (*c.* 1491–1556), and, sanctioned by the pope in 1540, went into action to try to recapture the New Learning for the Catholic religion. The Inquisition, a medieval church organization for detecting and punishing heretics (which had been revived with ferocious efficiency by Torquemada [1420–98] against Jews and Moors in Spain from 1481), was reorganized in 1542 to deal with the Protestant heresy. It could not be introduced into any state except by leave of the ruler, and was never admitted, for instance, to France. But all scholars, and all other men who expressed religious doubt or non-Catholic opinion, had thenceforward to reckon with this formidable power if they were within its reach.

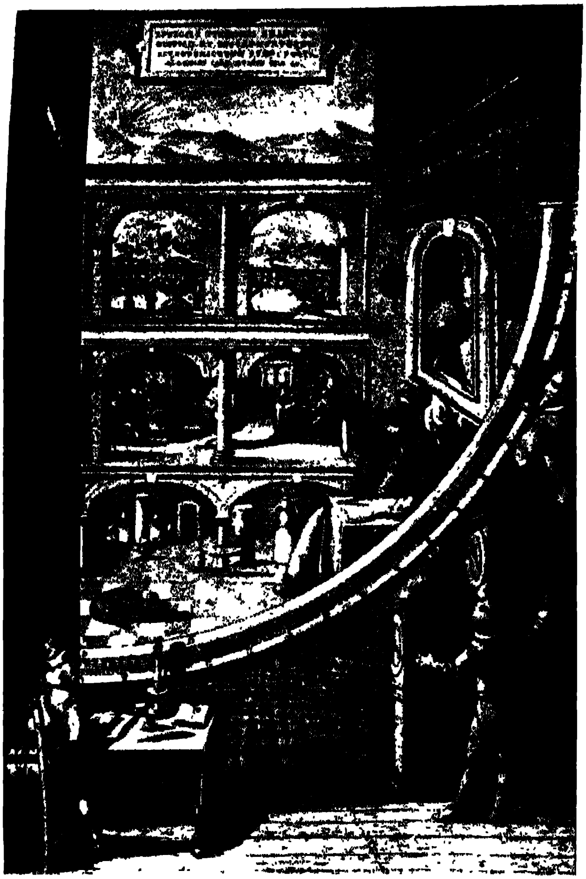
Art of Medicine

The New Learning was nowhere more needed than in the contemporary art of medicine, of which Desiderius Erasmus (1466–1536) wrote that it was "but one incorporated compound of craft and imposture." At Basle, Erasmus had for a while a colleague, a professor of medicine in the university, who is usually called Paracelsus (a name he gave himself, probably to claim superiority over Celsus, a distinguished Roman physician and writer of the Augustan age). Paracelsus left two reputations, now difficult to sort out; one shows him as a wise teacher, the other as a superstitious charlatan; he was expelled from Basle as a heretic of his profession, and wandered about Europe until 1541, when he died at Salzburg. Certainly he broke with the medical conventions of his time; he studied chemistry and botany, gathered information concerning simple country remedies, and was a precursor of Joseph Lister (1827–1912) in requiring cleanliness in the treatment of wounds.

Persecuted Turn Persecutors

Other medical pioneers were Andreas Vesalius (1514–64), a Belgian professor of anatomy at Padua, who was driven from his chair by the Inquisition and accidentally drowned on his way back from a pilgrimage of penance to Jerusalem; and Michael Servetus (1511–53), a Spaniard, physician to a French archbishop, who became a Unitarian (i.e. he believed Christ to be a man, not an aspect or part of Deity). Taking refuge at Geneva, Vesalius was condemned by the Calvinists, who were Trinitarians, and burnt at the stake. An ugly feature of the Reformation was that some of the leaders of churches persecuted by Rome turned persecutors themselves when they had the power. An instance where Catholic and Protestant alike rounded on a high-minded thinker was that of Giordano Bruno (1548–1600), a Neapolitan friar whose progress in philosophy carried him out of the Christian Church. Excommunicated by the Lutherans in Germany, he returned to Italy, and was imprisoned by the Inquisition and then burnt as an unbeliever.

Seventeen years after Nicolaus Copernicus died (1543), a Danish student, the son of a nobleman, bought at Copenhagen a copy of the



TYCHO BRAHE'S OBSERVATORY. This illustration from "Cosmographia Blaviana" (Amsterdam, 1662) is of the interior of the observatory at Uraniborg ("castle of the heavens") on Hven island, in the sound near Elsinore, erected by King Frederick II of Denmark for the Danish pioneer astronomer.

De Revolutionibus. This was Tycho Brahe (1546–1601), who studied astronomy in various German cities and was eventually helped by Frederick II of Denmark to build an observatory on the Danish island of Hven. Here for 20 years he made observations, collected data, and invented astronomical instruments. On the king's death he was driven from Denmark, and in 1599 the emperor Rudolf II invited him to work at Prague. There Tycho Brahe had an assistant, Johann Kepler (1571–1630), a German from Würtemberg, who had already lectured in astronomy at the university of Graz in Styria, and had lost his employment when that university was turned from Protestant to Catholic.

Tycho Brahe bequeathed to Kepler his vast accumulation of material, and the task of editing and completing the records afterwards called the Rudolphine Tables in honour of the emperor. These tables were the precursors of the modern Nautical Almanac. From Brahe's material Kepler evolved the three fundamental laws of planetary motion that made possible Sir Isaac Newton's (1642–1727) *Principia*. In 1612 Kepler lost his patron; poverty and family misfortune overtook him, and his aged mother was imprisoned on a charge of sorcery. He wrote astrological pamphlets for a living, but managed to publish an exposition of the doctrines of Copernicus, together with his own discoveries. This book, with the *De Revolutionibus*, was placed on the Catholic Index "Librarum Prohibitorum" in 1615. Kepler died at Ratisbon in Bavaria, unable to recover large arrears of money due to him at Prague.

Galileo of Pisa

Kepler dared to show that a planet's orbit was an ellipse—not a circle, as it had been described by Aristotle. His contemporary Galileo (1564–1642), a native of Pisa, who as a student enunciated the law of the swings of a pendulum, became professor of mathematics there before he was 26. He used the famous Leaning Tower for a dramatic refutation of Aristotle's (384–322 B.C.) claim that weights governed the speed of falling bodies. Galileo's one-pound weight and his hundred-pound weight hit the pavement together; but the Pisan authorities were outraged, and Galileo had to resign and find another chair of mathematics at Padua, in the territory of Venice, which at that time was politically hostile to the papacy. There he remained for 18 years, having at one time 2,000 students. There he made an efficient thermometer, and applied the accidental discovery of the Dutch optician Jan Lippershey (died 1619)—that a view through two lenses can enlarge an image—to the construction of the first telescope. He adopted Copernicus's theory that the earth is a very small part of the solar system; and he lectured in Italian, not Latin. He discovered the Milky Way to be composed of "star-dust," found sun-spots, deduced the rotation of the sun, and observed four satellites of Jupiter.

Galileo and the Inquisition

Invited to become court mathematician and philosopher at Florence by the Grand Duke of Tuscany, Cosimo (de' Medici) II, Galileo fell into the clutches of the Inquisition, and was forced to cease teaching that the sun was immovable and that the earth moved round it, since this doctrine was contrary to Holy Scripture. Some years later he unwisely wrote

a "dialogue" in which the Ptolemaic and Copernican systems were discussed. Although 70 years old and a Catholic, he was summoned to Rome a second time, and compelled to recant on his knees. The story that he muttered "Nevertheless it moves!" is an invention.

His recantation was read publicly in cathedrals, churches, and universities; he was condemned to imprisonment for life, and died blind. His son destroyed most of his prison writings, but a pupil preserved the treatise on the mechanics of motion which formed the foundation of Newton's immortal work on the laws of universal gravitation. Shortly before the great astronomer died he was visited by a young Englishman, John Milton (1608–74), who wrote of him as "a prisoner to the Inquisition for thinking in astronomy otherwise than the Franciscan and Dominican licensers thought."

LANDMARK IN SCIENTIFIC PROGRESS. The great age of scientific discovery in England opened with the foundation of the Royal Society by Charles II in 1662. His signature, with that of his brother James, is inscribed on this page of a book containing the signatures of the Fellows.

Courtesy of the Royal Society

Galileo and many others were checked or silenced in their contribution to what was called the "new philosophy," but the spirit of discovery, experiment, and invention was at large, and could not be controlled by Rome or Geneva. Francis Bacon (1561–1626), the lawyer and scholar who rose to be Lord Chancellor of England and fell from office because he accepted bribes, showed in his writings, *The Advancement of Learning* and *The Novum Organum or New Instrument for the Interpretation of Nature or the Discovery of Truth*, a tremendous intellectual range, including an almost supreme mastery of language, a profound understanding of methods of scientific inquiry, and a realization that there were "laid up in the womb of Nature many secrets of excellent use" beyond the comprehension of his time. His own scientific work was small, and he rejected the Copernican theory of the universe and derided the work of Kepler and Galileo, but he was the prophet of scientific ages to come.

Harvey's Researches

The earliest result of Bacon's writings was the formation of the Royal Society of London for the Improvement of Natural Knowledge, incorporated in 1662. A younger contemporary of Bacon was Dr. William Harvey (1578–1657), whose researches into the anatomy of dogs, pigs, lobsters, shrimps, frogs, snakes, slugs, oysters, and embryo chicks led him to lose most of his medical practice and to win lasting fame by his demonstration (1628) of the circulation of the blood.

From the time of Roger Bacon to the time of Newton the tides of knowledge and understanding had widened and deepened among the educated classes of Europe. The peasants still lived with their pigs, if they were lucky enough to have any pigs. Only the preponderance of agricultural workers over others prevented the extinction of mankind during the greater wars and pestilences. As it was, broad tracts of country could generally be devastated without actual starvation of anyone but the peasants themselves. The drudgery and hardship of medieval peasant life is difficult to imagine in the 20th century, except for those who have seen it more or less re-created by modern warfare. It is easy to say that peasants could resist cold and hunger like animals, but their crafts and skills were always the basis of settled civilization, and their knowledge of the soil and the seasons was the starting-point of progress.

WILLIAM HARVEY. His fame rests on his discovery of the circulation of the blood.

A Dutchman, Leeuwenhoek of Delft (1632–1723), saw through self-made microscopes the capillary links of arteries and veins denied to Harvey's vision, and was able to describe these as well as the red corpuscles. He also did much to discredit the idea of "spontaneous generation," by proving that the flea comes into existence in the same way as other insects, and is not engendered by dust or sand or pigeon-dung; also that eels do not emanate from dew or shell-fish from mud.

The Italian Torricelli (1608–47), friend and pupil of Galileo, improved both telescope and microscope and invented the barometer. Robert Boyle (1627–91), one of the founders of the Royal Society, discovered the law that the volume of a given mass of gas at a fixed temperature, multiplied by the pressure, is a constant quantity, a law which is known by his name, and also began the practice of modern chemistry in his laboratory. Hermann Boerhaave (1668–1738) won world-wide reputation by his books on human ills and their alleviation.

Newton the Pioneer

The greatest scientific name of the age is that of Sir Isaac Newton (1642–1727), pioneer worker in mathematics, optics, and astronomy, formulator of the law of gravitation—suggested to him, so the story runs, by a falling apple in his garden at Woolsthorpe in Lincolnshire—and modest discoverer of many another secret of nature. "I know not what the world will think of my labours," he wrote towards the end of his long life, "but to myself it seems that I have been but as a child playing on the seashore, now finding a smoother pebble, a prettier shell, than another, while the immense ocean of truth lay all unexplored before me."

When Christianity became the official religion of the Western world, the great mass of the common people—that is, the peasants—were at first little affected by the change. Their lords had embraced a fresh faith, and as their lords' property they were baptized by the Christian priests. But their conversion was often only nominal; many of them continued to believe in the "old religion" practised by their ancestors for thousands of years. This religion usually consisted of belief in a great mother-goddess and her husband or son—a god who died in autumn, was mourned in winter, and was greeted with joy when he was re-born in the spring—together with belief in local deities of woodland, spring, or mountain.

SIR ISAAC NEWTON, mathematician, physicist, and astronomer, rose from obscurity to become the most distinguished scientist of his day. In 1666 he began the researches which resulted in his formulating the law of the operation of gravity.
National Portrait Gallery

The Olympian gods and goddesses mostly arose from these simple beginnings, taking new forms in the world of towns and ships and conquest and commerce; when they passed, the country people still had their magics and fertility rites, their god who came and went, and their goddess who was always there. Christian missionaries, in order to facilitate the process of conversion, gave reluctant blessing to many a rite and tenet of the old beliefs which could be imported into the new without too much incongruity.

For centuries, then, the common people were pagans beneath a veneer of Christianity, but as the Christian rulers grew stronger and the Western Church spread its civilizing influence more widely, the old beliefs became a scandal and a challenge to the priests of the new. The fertility rites they could not tolerate; the need of a goddess, of a motherly presence in a religion dominated by the idea of a masculine father-god and a male priesthood, they tried to counter by, as it were, promoting the Virgin Mother Mary, who was entitled Theotokos, the Mother of God, after the Council of Ephesus in 431.

Hounding the Witches

In the 13th century the Inquisition was established; one of its first duties was the combating of the witch-cult. During the next three centuries thousands of unhappy people were charged with practising witchcraft, interrogated, tortured, and executed. The process of religious purification or persecution reached its height in the 16th century, when Romanists and Protestants vied with each other in hounding the "witches." Records state that in the small bishopric of Bamberg 600 witches were executed in six months; 500 perished in Geneva in 1515; at Toulouse 400 died at a single execution; and a judge of Nancy boasted of having condemned to death 800 witches in 16 years. At Como a thousand were executed in a single year, and as late as 1670 a number of witches were burnt in Sweden. Perhaps some of these figures are exaggerated, but the volume of cruelty and misery involved had to wait for the 20th century war-time Nazi regime for anything like a parallel.

The medieval concept of a witch was of a person—generally a woman—believed to have entered into a deliberate compact with Satan, the Evil One, to work his will in return for material gain, lustful pleasure, or power for evil over others. In the course of centuries the god of the witches thrust his goddess-partner into the background, although she remained as the chief witch of the coven (the unit of a separate witch-congregation, usually numbering about a dozen). The ubiquity of the Devil is easily explained: male witches dressed themselves up to make converts and to lead the nocturnal rites in lonely places. The dancing man, clothed in a stag-skin and crested with antlers painted in the Cave of the Three Brothers in the department of Ariège (French Pyrenees), and dating from Palaeolithic times, attests the fathomless ancestry of this form of magical religion. During the witch-trials thousands of the accused testified to having seen the Devil—sometimes in the form of an animal, sometimes as a black man, or as a woman, young and beautiful; everyone had heard of devil-possession, and some declared they had met children whom Satan had begotten.

WITCHES' RITUAL. This miniature from a French 15th century treatise on witchcraft shows the ceremonial adoration of a goat at a witches' sabbath. Sometimes a goat impersonated the devil or was sacrificed as the god incarnate; sometimes a man was dressed as a goat. Twelve witches are present at the meeting illustrated above; with the goat-devil they made a gathering of thirteen, or one "coven." A coven (apparently from the same root as convene) was the unit of the witch organization.

Bodleian Library, Rawlinson MS, D 410

Minor devils were numerous; they assisted in the rites, and sometimes took human spouses. Many a witch died at the stake for alleged sexual intercourse with an incubus or succubus, as the male and female devils were styled respectively. The word "nightmare" is a reminder of this belief, *mara* being the Old High German word for incubus, defined as a male demon that was supposed to consort with women in their sleep.

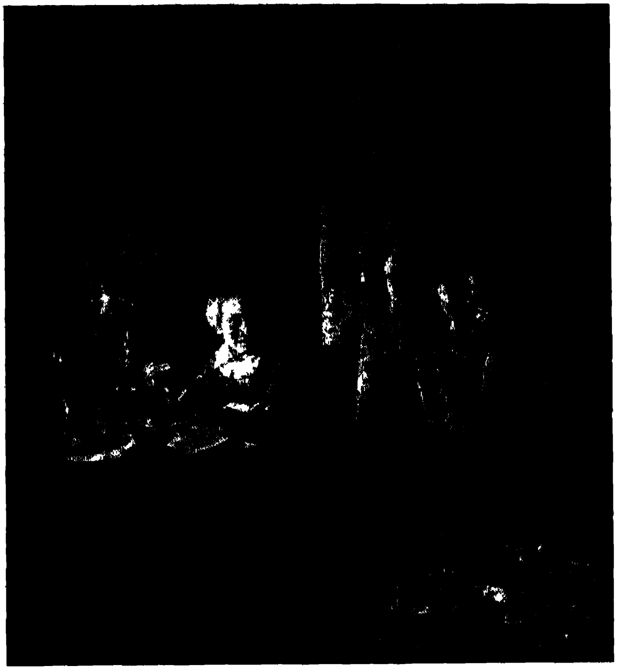
Official View of Witchcraft

A remarkable feature of some of the trials was the witch's steadfastness of belief in the Devil and refusal to deny allegiance to him, with the implied solace afforded by adherence to the old religion. The French historian Jules Michelet (1798-1874) wrote: "But for his belief in the Devil, the medieval peasant would have burst," and it may be that the seasonal orgies were indeed the one bright spot in the taxed and trampled and vitamin-deficient lives of the agricultural drudges of Europe who had not found consolation in the Christian religion.

The following quotation gives the official view of witchcraft as it was stated by Pope Innocent VIII in 1484.

"It has come to our ears that numbers of both sexes do not avoid to have intercourse with demons Incubi and Succubi; and that by their sorceries and by their incantations, charms and conjurations, they suffocate, extinguish and cause to perish the births of women, the increase of animals, the corn of the ground, the grapes of the vineyard and the fruit of the trees, as well as men, women, flocks, herds, and other various kinds of animals, vines, and apple trees, grass, corn and other fruits of the earth; making and procuring that men and women, flocks and herds and other animals shall suffer and be tormented both from within and without, so that men beget not, nor women conceive; and they impede the conjugal actions of men and women"

The physical circumstances of medieval life favoured the growth of delusions; a mass of concepts involving the power of suggestions, the degradation of practices originally devout in a magical sense, the action of toxic drugs on half-starved bodies and minds already prone to visions and compensatory dreams, the spite and malice and jealousy of the oppressed, the corruption of power in the minds of quacks and adventurers, the fervour and exaggeration of the honestly horrified or furtively sadistic upholders of law and justice—all these went



PREPARING FOR THE WITCHES' SABBATH. Beliefs of the period about witchcraft are included in this picture by the Flemish artist David Teniers the younger (1610-90). It shows the ritual supposed to take place on Walpurgis Night. In the background a naked witch is being anointed with the magic salve devised to enable her to fly up the chimney on a broomstick.

to the extraordinary history of the witch-cult and its suppression.

It is impossible to establish the proportion of peasants who attended the witches' "sabbaths" or seasonal gatherings, and the proportion of those attenders who cynically or nervously also went to church; but in no treatment of social life up to the 16th century can this side of human activity be lightly dismissed. While Michelangelo painted his tremendous frescoes for the pope on the ceiling of the Sistine Chapel in the Vatican at Rome, and Erasmus wrote his treatise on the education of a prince to acknowledge his appointment as an honorary councillor to the young Emperor Charles V, and Copernicus lectured to his 2,000 students, less enlightened men among their contemporaries were using against women accused of witchcraft the thumbscrews, the "boots" in which legs were broken by wedges, and the brazier over which the victim was roasted. Scourgings, prickings all over the body in search of the insensible spot which would be an infallible proof of guilt, duckings in rivers when the trussed accused could prove innocence only by sinking to the bottom, the infliction of such torments was a token of the Devil carried about in the hearts of men who professed themselves his enemies. These things fill a black and terrible chapter in human history.

LESSON 18

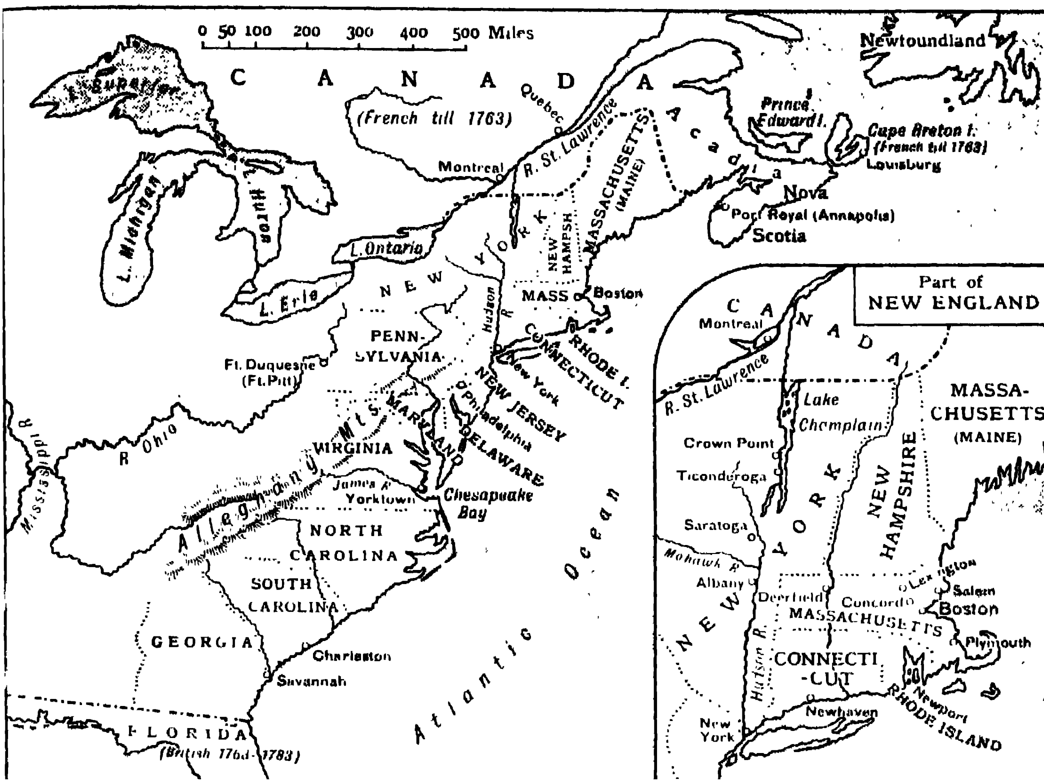
Early Colonies in North America

When North America was discovered—or rather rediscovered, for there is little doubt that 500 years before Columbus and Cabot, voyagers from Scandinavia via Greenland had reached Labrador and established settlements much farther to the south—the vast continental plains were the home of tribes of nomads, whom the newcomers called Indians.

Pilgrim Fathers

Little was done in the way of colonising the northern half of the New World until in 1605 the French established their first settlement in Nova Scotia. Within a few years English adventurers were making good their footing in Virginia and Newfoundland, and in 1620 the Pilgrim Fathers (ancestors of many of America's oldest families) made their historic voyage from Plymouth to Cape Cod in the tiny *Mayflower*. Their enterprise encouraged other men and women determined to find a land where they could worship God in the way they thought best, unmindful of the dictates of king or state-established church. Many more were inspired by love of change and adventure, or by the hope of bettering their fortunes in a country where there was no unemployment and land was to be had for the taking. Most of the newcomers were from Britain, but the Swedes had a colony on the Hudson; and New York, founded by Dutchmen in 1621,

MODEL OF THE "MAYFLOWER," the vessel in which the Pilgrim Fathers sailed.



EUROPEAN COLONIES IN NORTH AMERICA. English colonisation of the North American mainland began in 1607 in Virginia. The Pilgrim Fathers reached New England in 1620, and Massachusetts, Rhode Island, New Hampshire, and Connecticut were gradually occupied. New Jersey was first settled by the Dutch in 1620, and New York was founded as New Amsterdam in the following year. Delaware was a Dutch foundation, but with New Jersey passed to the Swedes, to the Dutch again, and then in 1665 to the British. Maryland (1634), North Carolina (1629), Pennsylvania (1682), and Georgia (1733) were all British in inception. French Protestants established in 1562 a fort—called " Arx Carolina," after Charles IX of France—on the coast of South Carolina, but they soon returned home and the colony was finally settled by the English in 1670. As Florida and Canada were ceded to Britain after the Seven Years' War, the whole North American coast was in British hands from 1763 until the War of American Independence.

was originally New Amsterdam—a neat little township of wooden houses roofed with thatch, with windmills and grog-shops where portly Hollanders smoked their long pipes and drank their schnapps.

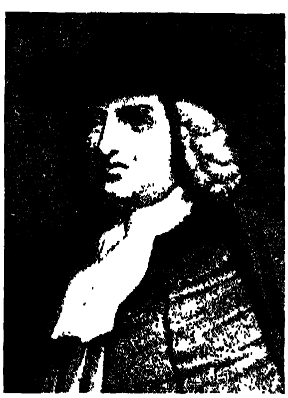
The Thirteen States

For a hundred and fifty years Canada was part of the French dominions. Up the St. Lawrence and across the lakes the trappers paddled their birch-bark canoes ; they sped on snow-shoes, accompanied by redskin guides, across the great plains, and in the forests their camp fires smoked and sparkled. Ahead of the coastal belt where the white man began to grow tobacco and cotton, corn and rice, and where he trapped and fished, the Indians roamed as they had done since they first came into the continent from Asia. There were wide differences between the settlements. From Virginia southwards they were essentially aristocratic ; white settlers, often the younger sons of old English families, cultivated huge estates by the labour of black slaves. The French colonies, almost feudal in structure, were little more than trading posts where furs were received in exchange for arms and finery. Maryland, named after the queen of Charles I, was founded in 1634 by the Catholic Lord Baltimore, and became a refuge for Roman Catholics ; there in 1650 the first Toleration Act in British history was passed by an assembly of Protestants and Catholics. The four original New England states—New Hampshire, Massachusetts, Rhode Island, and Connecticut—were predominantly Puritan.

New Jersey and Delaware were originally Dutch, but were seized by the British in Charles

PENN AND THE INDIANS. His conciliatory attitude towards the Indians whom he dispossessed was an exemplary feature of William Penn's colonial policy. This engraving from the painting in Independence Hall, Philadelphia, by Benjamin West (1738 1820) represents Penn's interview with the Delaware Indians in 1683.

II's reign, whereupon New Amsterdam became New York, in honour of the king's brother, the Duke of York, to whom the territories were granted. The Carolinas, after several unsuccessful attempts, were settled by aristocratic grantees of Charles II, and rapidly became centres of production of tobacco, rice, and cotton. The area north of Maryland and west of the Delaware, later to be given the name of Pennsylvania, was first Swedish and then Dutch, and passed with other Dutch possessions in North America to England. It was granted by Charles II to William Penn, an admiral's son who had become an ardent Quaker, in satisfaction of claims upon the English government inherited from his father. In 1682 Penn landed in his new dominion, met the local Indians in peaceful conference, and laid the foundations of Philadelphia (Greek : *brotherly love*), the capital of a Quaker state. After two years spent in organization and negotiation with the neighbouring colony of Baltimore, Penn returned to England. From the first the Quaker principle of toleration was observed in the new colony. Eventually Georgia, the most southerly of the 13 states destined in 1776 to declare themselves the United States of America, was founded in 1733 by a philanthropic English soldier, General James Oglethorpe (1696 1785), as a refuge for poor debtors and persecuted German Protestants.



WILLIAM PENN (1644-1718). He founded Pennsylvania as a haven of refuge for his fellow-religionists and other persecuted folk. He was buried at Jordans, Bucks.

Social and Economic Differences

Differing widely in origin, in racial composition, and in religion, the colonies were governed on much the same lines, for in most there were a governor appointed by the Crown, and upper and lower houses, members of the latter being generally elected by popular vote. Another common factor was use of the English tongue ; but to this again there were many exceptions, for immigrants from Europe often continued to speak their own language. In Georgia there were thousands of German-speaking citizens. There was no common established church ; in most of the states one or other denomination secured predominance.

There were social and economic differences, In the north and centre of the civilized fringe the town-dwellers—merchants and shop-keepers, clergy and teachers, artisans and fishermen—lived in contrast with the country-folk,

the struggling farmers who themselves produced practically everything they needed, from food and clothes to nails. In the southern states, Virginia and the Carolinas, the very different climate and soil produced a very different social picture. Tobacco was the most profitable crop, and as this rapidly exhausted the soil, new land was constantly sought by the planters; huge estates were acquired, and fortunes in crops and slaves assembled. In this way arose a planter aristocracy that had many points in common with their contemporaries among the English country gentry.

FATHERS OF COLONIES. Left: Cecil Calvert, 2nd Lord Baltimore (1606-75), the effective founder of Maryland. The child is his son. Right: General James Oglethorpe (1696-1785), who established Georgia in 1733 as a home for debtors and oppressed German Protestants.

Frontiersmen

From river wharves they shipped tobacco to their agents in London, receiving in return London dresses, books, and pictures, and London ideas of good living. In and out of slave-tilled fields they hunted the fox in English fashion, and at night they gathered at dance and party in their stately timbered mansions. Townsmen and countrymen, hard-bitten northern traders and easy-going southern planters, themselves threw up a line of skirmishers—the frontiersmen, pioneers with axe and gun, who constantly pushed the edges of civilization farther to the west. Before the revolt against Britain, and still more so after it, they were reinforced from across the Atlantic by youngsters and roving spirits, debt-burdened farmers and broken merchants, who looked eagerly across the ocean to the millions of acres available for cultivation where only Indians hunted the bison.

Wave after wave of immigrants passed to the west. Through the frontier towns went an almost endless progress of "movers," in wagons, on horseback, or on foot. Arrived at a spot they fancied, they erected a fort and palisade, cleared the land, built log huts, and planted crops. Towns and villages sprang up with

VIEW OF NEW YORK ABOUT 1661, when it was still New Amsterdam, a Dutch township of wooden houses. The panorama below "South Prospect of Ye Flourishing City of New York," published in 1746 shows the progress that was achieved in eighty years or so. This view was taken from that part of Long Island that is now Brooklyn.

amazing rapidity ; commerce developed, new states were founded, generation after generation felt the pull of even more remote country. And then, in the middle of the 19th century, the American flag waved from the Atlantic to the Pacific.

So different were the earlier American states that it is somewhat surprising that they ever came together to form a union. If it had not been for the ill-advised action of a British government, the whole of North America might still be British-controlled, as likely as not, from a capital perhaps on the banks of the Hudson river, in Canada.

LESSON 19

Diderot and Voltaire

BOOKS multiplied apace during the 16th century. In the following century some enterprising publishers conceived the publication of a book or books containing *all* the knowledge in all the world. The aim was not absurd in those days ; science was hardly born and so little was certainly known. So the first encyclopedias came into being, at first written in Latin but later in the so-called vulgar tongues, with their matter alphabetically arranged. The first English encyclopedia was published in 1703. A quarter of a century later Ephraim Chambers (1680–1740) issued a *Cyclopaedia* which was the basis, through a French translation, of the famous *Encyclopédie* which played so large a part in the stimulation of the French intellect in the 18th century, and may thus be regarded as one of the prime causes of the French Revolution.

Diderot's Encyclopedia

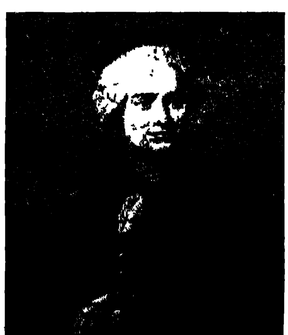
The editor of this epoch-making work was Denis Diderot (1713–84), a journalist who wrote novels and plays, critical essays and philosophical treatises, with apparently equal ease. He was appointed to the post by a bookseller, Le Breton, who had in mind merely a French version of the Ephraim Chambers production, but it was soon apparent that Diderot contemplated something widely different. Gathering about him most of the leading French authors of the time, he set them to work to produce not merely a storehouse of facts but an engine of reform in Church and state.

For 20 years Diderot coped with his Herculean task. He it was who decided the topics and allotted them among the numerous contributing staff ; shaped the articles ; corrected the proofs ; chose the engravings and gave them their captions. Confronted by enormous difficulties, doing what no man before had even attempted ; living under the shadow of long-promised prosecution, ready to flee at a moment's notice if the police should come to arrest him, Diderot persisted in his great enterprise, which was aimed at the enlightenment of mankind and the inauguration of the Age of Reason.

In 1751 the first volume appeared. It was searched through and through for treason and heresy. Six months later the second volume followed, and was likewise subjected to close scrutiny. Then the opposition made itself heard. " The Faith is not attacked," said the clerics. " Diderot is too devilishly clever for that ; but he tries to *explain* it. And, besides, he assumes that his readers will be in favour of toleration—of all creeds and of none ! "

" What's this ? " said the king's ministers. " This low-bred fellow writes as if in a modern state the meanest should be free, and dares to suggest that the inventor of some paltry machines deserves more of his country than a soldier ! " From pulpit and press poured denunciations. In council chamber and royal drawing-room plots were made to silence the dangerous scribbler and his hired subverters of Church and state.

Among his presses Le Breton felt himself in danger if future volumes were to appear uncensored. He took counsel with his foreman; and at night after Diderot had gone, the two went through the proofs and cut out every



EDITORS OF " L'ENCYCLOPÉDIE." Left : Denis Diderot (1713–84), joint editor with d'Alembert (right) of the great French Encyclopedia (1751–65). His best-known writings are " La Religieuse," " Le Neveu de Rameau," and " Pensées Philosophiques." Jean le Rond d'Alembert (1717–83) was a relativist in philosophy.

ILLUSTRATIONS FROM DIDEROT'S "ENCYCLOPÉDIE." Below, a loom for cotton weaving, such as might be found in many an 18th-century cottage in rural France, the materials being provided by an employer or middleman. Right, interior of a small bakery: workers are kneading and weighing dough, making up and baking loaves.

passage, every phrase, every line, which in their timorous judgement was likely to incur the hostility of the government. Not for a long time did Diderot discover their handiwork, and then it was by chance one day when he happened to refer to an article of his own under the letter S. The passage he sought was no longer there. Excitedly he turned the pages, and realized what had been done. After a furious scene with Le Breton, he gave up his work in despair.

Confiscated Volumes

After a while he was persuaded to continue, but not with the old enthusiasm or pride. Nevertheless, as volume was added to volume, the fame of the great work spread; its influence grew despite the opposition of those who saw in it the beginning of the end of their world of privilege. On one occasion a royal edict directed that every subscriber must hand his set to the police pending the king's decision as to whether or not the work was fit to be read by his loyal subjects. With much grumbling the order was obeyed; presently the confiscated volumes were returned as the result, so Voltaire tells us, of an examination made during a royal supper party at the Trianon, which revealed their usefulness as a source of information on such varied topics as the composition of gunpowder and face-powder, the method of working of a stocking-frame, and the rights of the monarchy.

Gifted Contributors

Contributions to the *Encyclopédie* included virtually all the leading French writers, the *philosophes*, of the time. D'Alembert (1717–83), the foundling boy who devoted his life to philosophy and mathematics, edited the mathematical section of the work and wrote the preface, which discusses the origin and classification of the sciences. His portrait appears as the frontispiece of the first volume. Turgot (1727–81) wrote on economics; he was the "Intendant" of Limoges who toiled to improve the lot of the downtrodden peasants, showed them how to grow the cheap but nourishing potato, and saw them through a dreadful famine. Years later—and years too late—he was called in by Louis XVI to administer the national finances, only to be dismissed after 20 uneasy months of office.

Jean Jacques Rousseau (1712–78) wrote on music; Jean Marmontel (1723–99), hated by religious bigots for his denunciation of atrocities committed in the Americas in the name of religion, contributed literary articles; and Montesquieu (1689–1755), author of what has been described as the most popular and original book ever published on the science of law, discoursed on taste. Diderot himself wrote hundreds of articles in addition to his colossal labours as editor. During the day he spent hours in factories and workshops, studying the construction and working of machines and mechanical contrivances of all kinds, and returned at night to his attic to describe them clearly and exactly.

The last volume of text appeared in 1765. The great work brought Diderot fame but little money, and he remained financially embarrassed until the empress Catherine II of Russia heard of his difficulties, bought from

PUBLIC TRIBUTE. Voltaire left Ferney to revisit Paris early in 1778. He wished to see his play "Irène" performed at the Comédie Française. On the way to the theatre he was mobbed by admirers shouting "Vive Voltaire!" The audience insisted on his being crowned, "the man unique in all ages," by Madame de Villette and the actor Brizard.

From a contemporary engraving in the Hennin Collection

him his library, and then left it in his custody in Paris with himself as its salaried librarian. For nearly twenty years he saw the *Encyclopédie* make its way in the world ; he died five years before his fellow-countrymen began to try to carry into practice ideas discussed in its pages.

Troubles of Voltaire

Most famous of Diderot's contributors was Voltaire, the pen-name of François Marie Arouet (1694–1778). Son of a well-to-do lawyer, Voltaire was educated in a Jesuit academy and launched on the gay and trifling world of the Regency (the boy-king Louis XV succeeded his great-grandfather Louis XIV in 1715, and his great uncle the Duke of Orleans was regent for some years). Thanks to his literary ability and wit, and to one or two influential friends in court circles, Voltaire soon began to make a name for himself as a bright young man-about-town. He wrote light verse and plays, had love affairs, spent nearly a year in the Bastille on a charge—apparently unfounded—of lampooning the regent, and then was thrown into the Bastille again for daring to resent a beating by a nobleman's lackeys.

After a short imprisonment he was released on condition that he left the country ; England, where he spent some three years, left an indelible impress on his subsequent thought and work. Compared with the France he had left, England was a land of freedom ; men could discuss almost with impunity things that were taboo across the Channel. When Voltaire returned to Paris in 1729, he held "advanced" views on politics and religion ; the remaining years of his long life were chiefly devoted to the propagation of those views on the Continent.

Philosopher of Ferney

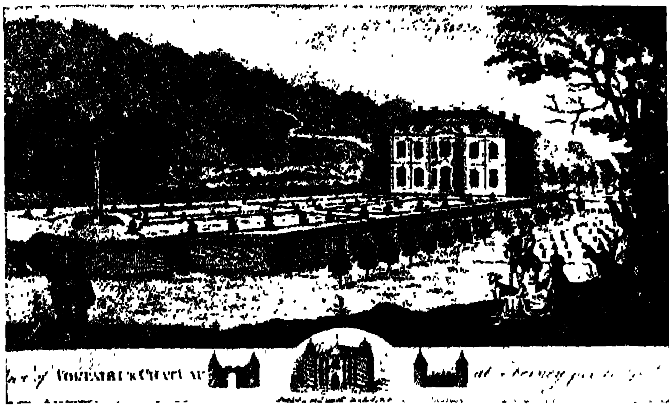
Plays and poetry, philosophy, criticism, and history poured from his brain and pen. He amassed a fortune by speculation in army contracts and in business, dabbled in science, was elected to the Academy and appointed historiographer to Louis XV. In 1750 he went to Berlin as the favourite *savant* of Frederick II, but a couple of years later the philosophers fell out, and shortly afterwards Voltaire settled near Geneva, first on Swiss territory and then at Ferney, four miles over the French border. Rich and already famous, he retired at the age of 64, but was disturbed in his retreat by news that publication of the *Encyclopédie* had been suspended by royal decree :

Then, worst of all :

"One of your poems has been condemned by the parliament and publicly burnt by the executioner.

"A man named Calas, a Protestant, has been found guilty of murdering his son, believed to be about to adopt the Catholic faith, and has been broken on the

ICONOCLAST AND REFORMER. This terra-cotta statuette in the Musée Carnavalet, Paris, shows Voltaire as an old man, pen in hand and crowned with the Phrygian cap of liberty. A serious portrait is in page 1768.



WHERE VOLTAIRE LIVED. A late 18th century picture of the house at Ferney, in which Voltaire lived from 1758 until a few weeks before his death in 1778. From it he directed his campaign against bigotry and despotism. He contributed to the great "Encyclopédie."

wheel, while his wife and children were put to the torture

"At Toulouse, the daughter of a Protestant named Sirven was taken away and shut up in a convent. Not liking her new home she drowned herself in a well. Her father has been charged with her murder but, warned just in time, has managed to escape into Switzerland. The mother, however, succumbed to her hardships in crossing the snow-covered mountains.

"On the bridge at Abbeville a crucifix has been mutilated. Three youths have been arrested and one of them, the Chevalier de la Barre, has been found guilty of the sacrilege. True, no one saw him do it, no one saw him on the bridge that night; but it was proved that he kept his hat on when a religious procession went past and, besides, he admitted singing an irreverent ditty. Then, too, he had a copy of your Philosophical Dictionary in his lodging and it was burnt with him . . . he was beheaded first, then burnt."

Thereupon the philosopher of Ferney came out of retirement and began the campaign which made him the champion of culture and enlightenment, the foe of superstition, whose enemies represented him as an indecent mocker of holy things, as a sneering, soul-destroying atheist. (As a fact, he was a consistent deist.) Voltaire saw in the Church, particularly in the Jesuits' organization, a repository of ignorant bigotry and indolent vice, supported by and using all the powers and privileges of the state. It was this conglomeration of superstition and fanaticism—not Christianity or Jesus—that Voltaire described as "the Infamous thing." "Crush the Infamous thing!" (*Ecrasez l'Infame!*) became the watchword of his life, the postscript of every letter.

From his study at Ferney he poured out pamphlets and articles, distributed by enthusiastic colporteurs wherever the French tongue was spoken. He lied, and adopted every other subterfuge, to win them circulation; he had them bound as books of devotion, issued under pseudonyms and counterfeit names (at least one purported to be from the pen of the Archbishop of Canterbury). He exposed the Calas case as judicial murder, and won some compensation for the unhappy man's widow, he championed Sirven, gave him and Mme. Calas a refuge, and laboured for years to clear the name of La Barre.

The civilized world rang with his appeals on behalf of those who had no claim upon him but that of common humanity; an amazing duel developed between the "infidel patriarch" and the massed battalions of Church and state. The spectacle moved even some of his enemies to admiration. When in the evening of his days he went to Paris for the last time and was greeted with delirious popular enthusiasm, the chief praise was not for his dramas, histories, verse, or philosophy, but for his humanity. "It was he who defended the Calas!"

LESSON 20

English Farmers Who Taught the World

Agriculturists held on to their methods of work, as well as to their traditional mixture of magic and recreation, much longer than the rest of the population. In parts of southern England, even divisions of the land dating from Norman times persisted as strips, great fields, commons, and waste, into the 18th century and sometimes later.

About the beginning of the Tudor period considerable alteration resulted from an epidemic of enclosures on the part of some of the big landowners, who were attracted by the profits that might then be obtained out of sheep-farming, and there were complaints, voiced as follows in Sir Thomas More's (1478-1535) *Utopia*, that the sheep—

"that were wont to be so meek and tame and so small eaters now become so great devourers and so wild that they eat up and swallow down the very men themselves; they consume, destroy and devour whole fields, houses and cities."

In other words, the peasantry were dispossessed in order that pasturage for sheep might be extended over great stretches of the countryside. But the Tudor enclosures seem chiefly to have affected only certain districts, mainly in the Midlands; and it is true to say


FARMING PIONEERS. Left: Robert Bakewell (1725–95). Born at Dishley, son of a farmer, he specialised in stock-breeding and produced improved types of cattle and sheep, and a breed of heavy horses. Right: Arthur Young (1741–1820). Born in London, he was interested in all agricultural matters and by his writings gave great impetus to farming progress. His "Travels in France," 1787–89, gave an unsurpassed picture of France on the eve of the Revolution, and his earlier "Tour through the Southern Counties," "Tour through the North of England," and "Tour in Ireland" are also valuable.

that the old medieval system of land-holding and husbandry continued in England until the 18th century. Growth of population then necessitated food production on a very much larger scale than heretofore.

Strips and Common Rights

The open-fields system of tillage had many grave disadvantages, which were accentuated with time. The fact that all the holders of strips were bound by customary rules as regards crops and their rotation meant that initiative and experiment were at a discount. Land was not put to the best uses, the strips were too narrow for cross-ploughing and harrowing, and the numerous balks that divided them were so much waste land. Drainage was almost impossible; weeds rioted on badly-tilled strips, on the balks and waste; the farm buildings might be far from the fields, and much time wasted in carting.

After the crops had been gathered, all the cattle of the community were allowed to wander over the fallow strips; this made it impossible to do anything in the way of improving breeds of cattle and sheep, and increased the dangers of infection and disease.

JETHRO TULL (1674–1741). Born at Basildon, Berks, he became a barrister, but from 1699 devoted himself to agriculture. In 1714 he settled at Prosperous Farm, near Hungerford. He invented a seed-sowing machine.

Royal Agricultural Society

Eventually boundaries were so involved and changed so often that quarrels and lawsuits were frequent. The advantages of the common lands have perhaps been exaggerated: they certainly enabled many a poor cottager to live by keeping his cow and pigs, but they also encouraged the idle and shiftless to live in squalor.

Change from the old state of affairs to the new might have been made far more equitable than it actually was, but it was bound to occur; better farming practice was essential to feed the growing population, and it involved the substitution of individual and compact farms for widely-scattered strips and common rights. The pioneers of the agricultural revolution in Britain—and, through Britain, of the world—the men by whose foresight and inventiveness millions of their fellows have been enabled to exist, are frequently ignored in shorter history books. The most eminent are named below.

Tull's New Methods

Jethro Tull (1674–1741), a Berkshire man, after leaving Oxford and doing the grand tour of the Continent, settled down of necessity in a "wretched hovel" on the Wiltshire-Berkshire border as a humble farmer, and there he studied with the aid of a small microscope the chemistry of plants, and vegetable physiology. He is chiefly remembered for his invention of the first practical sowing-machine, and for his advocacy of constant tillage by means of the hoe an operation much easier and more effective when the seed was sown, by his newly invented machine, in regular rows. He described his system in *Horse-hoeing Husbandry* (1733), a book which influenced many of the greater landlords. In the main Tull's life was a struggle with nature and with inefficient, suspicious, and often hostile labourers.

Tull's methods were particularly suited for turnips, which were just beginning to be extensively cultivated as a forage crop, and his methods were followed by Lord Townshend when in 1730, disgusted with the political life of the Walpole régime, in which he had played

ENGLAND BEFORE THE ENCLOSURES. These engravings by David Loggan, dating from about 1675, are of the country around Cambridge in the pre-enclosure days, when the medieval system of open fields still prevailed. The lower view shows corn being reaped by the village farmers. At the top is a series of open fields from which the crops have been gathered, now roamed over by huntsmen and the peasants' livestock.

a very considerable part, he deserted politics and retired to his estates at Raynham in Norfolk. There in a few years he converted an area of marsh and sandy waste—where, it was said, two rabbits struggled for every blade of grass—into a fertile and highly cultivated tract.

Townshend marled and manured, ploughed and hoed ; he started the Norfolk or four-course system of crops, doing away with the wasteful necessity of fallow ; he grew turnips with such assiduity and success that he is remembered to-day not as a one-time secretary of state and lord-lieutenant of Ireland, but as "Turnip" Townshend. He would not have complained of this honourable nickname.

Bakewell's Achievements

A little later in the 18th century Robert Bakewell (1725-95), a Leicestershire yeoman, revolutionised the practice of breeding and rearing stock. Up to this time stock-breeding might be described as " the haphazard union of nobody's son with everybody's daughter." Sheep were bred for their wool --long-legged specimens were preferred because of the bad roads—and cattle for their powers as draught animals. Bakewell devoted himself at Dishley to breeding ; and eventually, by using only the best specimens of each breed, he produced New Leicester sheep, ready for market in two years instead of four, and Dishley or New Leicester cattle, not such good milkers as some other breeds, but far superior for quantity and quality of beef. For years he derived a large revenue from his stud of stallions, bulls, and rams. The friend and master in the farming art of many of the great and wealthy of his time, he yet fell on evil days and died in poverty. Few men of his century did better work for the supply of food than this very John Bullish farmer, who dressed in a brown coat, scarlet waistcoat, leather breeches, and top-boots.

Young and Coke

Arthur Young (1741–1820), who wrote distinguished works based on his tours in England, Ireland, and France, published many novel ideas in farming practice ; his monthly *Annals of Agriculture* had as a contributor one Ralph Robinson, none other than George III himself. Young urged that every obstacle in the way of improved farming must be swept away in the interests of the fast-growing urban population.

More or less contemporary was Thomas Coke (1754–1842)—Coke of Norfolk—who in 40 years transformed his Holkham estate from something very near a waste into one of the finest wheat-producing areas in the country.

It has been noted that some enclosures were made in Tudor times. During the next two hundred years the process continued, particularly as regards land suitable for wheat cultivation. After about the middle of the 18th century the enclosure movement received an immense impetus from the good prices obtainable for meat and wheat. In those days few people thought it possible, let alone desirable, that England should come to rely upon foreign countries for her food supply, and so every effort was made to stimulate home production.

The earlier enclosures were nominally made by agreement, i.e. the squire or big farmer who wanted to enclose land persuaded, by money or other means, the yeomen and commoners affected to give up scattered strips and common rights to enable him to form a compact area. This slow and cumbersome method was superseded after about 1760 by enclosure by act of parliament. Between 1750 and 1793 some 1,355 enclosure acts were passed ; between 1793 and 1815 about 1,934.

Small Landholders

As enclosure acts were passed by parliaments composed largely of big landlords, the complaints of the small landholder generally went unheeded. The times demanded farming on a big scale ; the cottar and the man who did a little farming in addition to working at a handloom found themselves driven by the threat of starvation to enter the factories and ironworks of the rapidly growing towns.

On the European Continent the agrarian revolution took a different path. It is estimated that in France, just before the Revolution in 1789, nearly two-fifths of the soil was already occupied by peasant proprietors. The proportion was increased when confiscated lands of the nobility and clergy were put on to the market. The land settlement of the Revolution was its most permanent feature, and it is responsible for the fact that France is still a land of small proprietors. The same remark holds true of Belgium, where the feudal system received its death-blow at the hands of the invading French in 1795. In the German countries the serfs were not finally emancipated until 1858, but for generations Germany has been a land of peasant farmers. Only in the eastern districts, where the Prussian Junkers (landowners) ruled, was there a predominance of large estates with tenant farmers after the English model.

" Green Revolution "

Emancipation of the Russian serfs was not granted until 1861, and the tsar's edict was by no means universally welcomed—largely because the peasants, as the price of their freedom, had to surrender to their former lords a part of the land which they had cultivated as if it were their own. Up to 1917 individual farms were rapidly taking the place of the communal system introduced by the *mir* or village organization, but the triumph of the Soviets meant a new agrarian revolution, promoting the collectivisation of farming on a grand scale.

Following the First World War (1914–1918) there was in the eastern half of Europe a widespread expropriation of big landlords, followed by the splitting-up of their estates into peasant holdings. In Austria, Hungary, Poland, Czechoslovakia, Finland, the Baltic States, and Rumania, this Green Revolution, as it was sometimes called, resulted in a vast extension of the area occupied by the small-scale cultivator. Britain stood out as the land where the husbandman did not usually own the land he tilled. Enclosures turned the English peasants into agricultural labourers.

LESSON 21

The Industrial Revolution

About half-way through the 18th century appeared what is universally known as the Industrial Revolution, a change of social and industrial life through the adoption of machinery in textile manufactures ; the use of steam-power to work engines in factory and at pit-head ; the growth of enormous new industries employing millions of pounds of capital and hundreds of thousands of workmen —iron and steel, industrial chemicals, textiles, coal, canals and roads and, later, railways and steamships ; and, eventually, the massing of great multitudes into hastily built and insanitary towns, where they lived short lives and bred swarms of unhealthy children.

It is impossible to give any entirely satisfactory answer to the question why the Industrial Revolution began when and where it did. No one invention brought it about, no one man gave it its impetus ; a number of favouring circumstances happened to exist together in the Britain of the day. These included large stores of capital awaiting fruitful employment, amassed in commerce with India and the Indies, derived from the slave trade and brought home by " nabobs " from India ; huge markets in the lands recently won by the pioneer empire-builders ; a number of inventions, making possible the production of goods on a scale incomparably greater than ever before ,

and a population of workpeop'e with long traditions of skilled industry and so vigorous that even the appalling mortality rate of industrial conditions could not prevent their numerical expansion.

In Britain the Revolution can be divided into two periods : first, from about 1760 to 1840, when the chief means of transport were the newly-built and developed canals and metalled turnpike roads ; secondly, the railway period, from about 1840 until the '60s or '70s, when the change-over had been in great measure effected —from road to rail, sailing vessel to steamship, domestic manufacture to factory production, national self-sufficiency to dependence upon imported corn.

On the European Continent the transformation is not so readily divisible and, generally speaking, did not take so long. The French and Germans were able to profit by British mistakes, but it took them generations to make up the leeway lost by the diversion of national effort to the Revolutionary and Napoleonic wars. The political revolution of 1789 may well have prevented France from taking the lead in the Industrial Revolution ; by the time France and Germany were ready to compete for industrial and commercial supremacy, Britain was the workshop, the shipper, the banker, and the market of the world.

Coal and Iron

Every department of the nation's industrial life was revolutionised in turn. First in time was the development of the coal and iron trades. The latter in the 18th century was dying out, as English timber grew scarce and patriots declaimed against the base industrialists who consumed in their furnaces oak that ought to have been converted into "wooden walls" for Old England. But between 1740 and 1750 the Darbys of Coalbrookdale devised a method of using pit-coal in their smelting works, and after 1760 the trade as a whole began to profit from the discovery.

About the same time James Watt (1736–1819), mathematical instrument-maker to the university of Glasgow, sat in his workshop in the university precincts, poring over a small model sent him for repair—a model of an engine made 60 years before by Thomas Newcomen (1663–1729), a Dartmouth blacksmith, in conjunction with Cawley, a glazier of the same town, and Savery, manager of a Cornish mine. He examined it for hours, mastered its working, realized its defects, and then spent months devising improvements that might be made.

In 1769, Napoleon and Wellington were born, but perhaps that year is more historically significant for patenting by Watt of the steam-engine—one of the epoch-making inventions of the human mind. In 1774, Watt allied himself with a business and engineering genius, Matthew Boulton (1728–1809) ; in course of time from their Soho ironworks in Birmingham emerged steam-engines—giants of labour which never tired, seldom required repair, and took many years to grow too old for service.

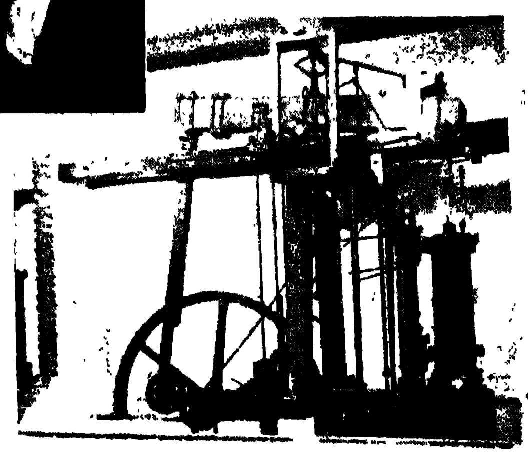
Children in Mines

Deep in the earth coal-begrimed men toiled with shovel and pick, digging the food of the steam monsters. Along the subterranean roadways (some 30 inches high, or less) women scrambled, pushing or pulling the heavy tubs to where the hewers were working, dragging back the loaded tubs, attached to their belts by chains passing between their legs. Children, too, carried coal on their backs up steep stairs to the surface, and worked underground, tub-dragging, or even at the coal face.

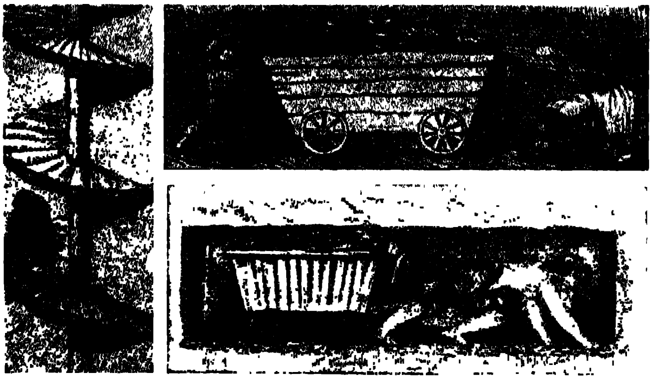
"I found," said a sub-commissioner in 1842, "down a narrow passage a girl of 14 years of age, in boy's clothes, picking down the coal with the regular pick used by the men. She was half-sitting, half-lying, at her work, and said she found it tired her very much, and 'of course she didn't like it. . . .' Whilst I was in the pit I saw another girl, of ten years of age, also dressed in boy's clothes. She was a nice-looking child, but as black as a tinker."

Boys and girls not yet in their teens—some as young as *four* years—worked ventilation traps, sitting for terribly long hours in the dark, ankle-deep in mud and water, listening to the squeaks and pattering of the rats.

"I am a trapper" (it is a girl of eight speaking). "I have to trap, without a light, and I am scared



JAMES WATT (1736–1819) took out his first patent for his steam engine in 1769, thereby inaugurating a new age. The rotative beam engine was made by Watt and his partner, Matthew Boulton, in 1797.



SLAVES OF THE INDUSTRIAL SYSTEM. Until 1842 women, and children under ten, were employed in British coal-mines. These illustrations from the Report of the Royal Commission of 1842 show children pushing heavy tubs, and carrying sacks of coal to the surface up spiral stairways, and women dragging tubs by means of chains passed round the waist and between the legs.

I go at four and sometimes half-past three in the morning and come out at five and half-past in the afternoon. I never go to sleep. Sometimes I sing when I've light, but not in the dark ; I dare not sing then . . ."

The increasing demand and production of coal for factories, ironworks, and potteries necessitated the provision of some means of transport other than carts and pack-horses. Hence between 1760 and 1820 there was an immense development in the British canal system. The famous Bridgewater canal—built by the third Duke of Bridgewater after the plans of the engineering genius James Brindley (1716 1772), to link up his colliery at Worsley with Manchester, and now part of the Manchester Ship Canal—was begun in 1761, and the duke followed it up with a second, joining Manchester to Runcorn on the Mersey above Liverpool. Before the close of the 18th century England was covered with a network of inland waterways, many of which later fell out of use.

At the same time the English road system was vastly improved, largely through the work of the turnpike trusts, i.e. corporations of persons empowered by parliament to reconstruct a certain stretch of road and recoup themselves with tolls demanded from the users of the reconstructed highway. The roads along which travelled the coaches described in romantic stories were nearly all turnpikes.

Two men should ever be remembered in connexion with these vast improvements: Thomas Telford (1757–1834), son of a Scottish shepherd and in turn a stone-mason, builder, public works surveyor, builder of canals and roads (the London to Holyhead road, the Conway and Menai suspension bridges, and the Caledonian Canal testify to his constructive genius) ; and John Loudon McAdam (1756–1836), who, after a successful career in commerce, developed a passion for road-making and invented the system known everywhere by his name.

Textile Inventions

The new British Empire overseas provided a huge market of millions of dark-skinned people, possible buyers of English cottons. The first sources of supply were country workshops and farmhouse kitchens, where women and children passed the long hours of winter before their simple looms, gladly deserting them in spring and summer for work in the fields.

Presently a remedy was found. Mills arose, and machinery began to clatter beside the streams of Lancashire and Yorkshire. The inventors who changed the face of the north country were Richard (later Sir Richard) Arkwright (1732-92), the one-time Bolton barber, who gave " a clean shave for a halfpenny " in an underground den, and visited country fairs in order to buy hair for wigs ; Samuel Crompton (1753-1827), who played the violin in a Bolton theatre, helped his mother with farm and loom, and became so exasperated at the deficiencies of the latter that for years he sat up late at night until he had thought out an improved spinning device ; James Hargreaves

BRIDGEWATER CANAL. Credit for the development of canal communication belongs to the third Duke of Bridgewater, who employed James Brindley to construct a canal from Manchester to the Duke's coal-fields at Worsley. Brindley's canal, begun in 1761, crossed the Irwell at Barton by means of the three-arched stone aqueduct seen in this contemporary engraving.

(1745–1778), the unlettered carpenter-weaver of Blackburn; and Edmund Cartwright (1743–1823), a Leicestershire vicar who preferred invention and manufacture to preaching (the hand-weavers wished he had kept to his pulpit, and they burned down his Manchester mill with its 400 steam-driven looms).

These, and many others unknown to fame, schemed and contrived, until throughout the world white and black and brown and yellow men and women were clothed in the products of their machines, and until wide areas of the northern counties took on a pall of smoke

EARLY POWER LOOMS. **Interior of a Lancashire cotton mill about 1830, when machinery and steam power had become the rule. The first power loom was evolved in 1785 by the Rev. Edmund Cartwright.**

From Baines's "History of the County Palatine of Lancashire"

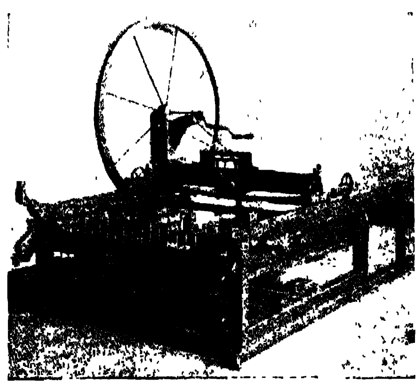
Coming of Railways

The second phase of the Industrial Revolution in Britain was marked by the coming and rapid development of railways. For thousands of years man had been dependent for locomotion upon his own legs and the legs of horses, donkeys, camels, and elephants; at sea he used oars and sails; the occasional balloon had already been floated by means of gas. Now steam and iron combined to carry him and his goods from place to place at speeds hitherto beyond consideration.

On September 27, 1825, the Stockton and Darlington railway was opened. Four hundred and fifty people travelled in the world's first passenger train, and the distance between the two towns—8¾ miles—was covered in 65 minutes. Fifty years later more than 16,000 route-miles of railway were in operation in the United Kingdom, and this continued to increase.

Like many another valuable invention, the railway in its early days was derided and abused. Men were not meant to travel so fast, said some; it was flying in the face of Providence; and when in 1830 William Huskisson, a British statesman, was run over and fatally injured at the opening of the Liverpool and Manchester railway, many people regarded the accident as a warning or a judgment.

Some towns did their utmost to avoid the railway; their reluctance explains the inconvenient siting of many a station. Landowners declared that the trains would spoil their shooting preserves and upset their livestock. But the new system of transport triumphed over every obstacle, so many and obvious were its advantages. Railway building developed into a mania; in one year during the 1840s some 270 railway promotion bills were introduced into parliament. The boom ended in a crash that brought ruin to thousands of unlucky investors. A railway clearing system was adopted in 1842 at the instigation of George Hudson, one-time draper in York, who became chairman of the Midland Railway Co. and Britain's "railway king." But he appropriated shares to his own account, and when the inevitable slump occurred, his defalcations were discovered and he had to go abroad. As a result of the "railway mania" parliament very reluctantly began to exercise some supervision over railway development, e.g. in 1845 the first workmen's trains were secured by enactment; and less populous districts were served by lines which otherwise might not have come into existence.



SPINNING-JENNY. **A model, at the South Kensington Museum, of the spinning-jenny invented by James Hargreaves and named after his wife**

First Steamships

The steamship ante-dated the railway. In 1802 the steam-driven *Charlotte Dundas* plied on the Forth and Clyde canal. Robert Fulton, an American engineer, designed a passenger steamer which, engined by Boulton & Watt, ran regularly on the Hudson river from 1807. But the sailing ship died hard and was

LIVERPOOL-TO-MANCHESTER RAILWAY. This railway, of which George Stephenson was the engineer, was opened in 1830. The proceedings were marred by the fatal accident that befell William Huskisson, a former Cabinet minister, who was killed by a locomotive at Parkside station, seen in this drawing made in 1833.

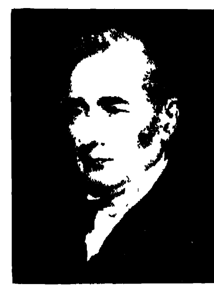
still the preponderant type up to the 1860s. Then the superiority of the iron steamship was demonstrated beyond all doubt, and the great sailing ships were eventually laid up.

So the Industrial World Was Born

As decade followed decade, Britain became more industrialised and urbanised. She enjoyed to the full the advantages that sometimes attend the pioneer. Her steamers, to be found on every sea, carried the produce of the world. Her coal heated every boiler, and was burned in millions of grates at home and abroad. Her engineers laid down the railways of the nations that were not yet her rivals, provided them with their machines and kept these in repair, lighted the streets of the cities with gas, installed their water supply and drains. Her clothing was sold in scores of countries, and her capitalists prospered exceedingly.

So the industrial world was born. The earth began to be plundered of treasures hitherto hidden—iron, new finds of gold, and many other minerals. The soil was compelled to bear crops such as it had never borne before. Villages became towns, towns became cities. New classes of wealthy merchants and skilled engineers appeared. Commerce itself expanded in countless directions.

For long centuries land had been the basis of power ; now it was dethroned by business. Cotton spinners and ironmasters, railway and shipping magnates and coal-owners, middlemen, bankers, and company-promoters - these became the rulers of the new world begotten by invention. They had money, country seats, and houses in town, titles and honours, carriages and yachts, servants by the score. But the mass of workers in the factories, mines, foundries, and workshops found life a grim struggle. The lot of these toilers has been described in some of Mrs. Gaskell's novels, in Charles Dickens's *Hard Times*, and in Disraeli's *Sybil*, in such contemporary writings as those of Engels and Marx, and in studies of the period by J. L. and Barbara Hammond, Sir Arthur Bryant (*English Saga*, 1943), and others.

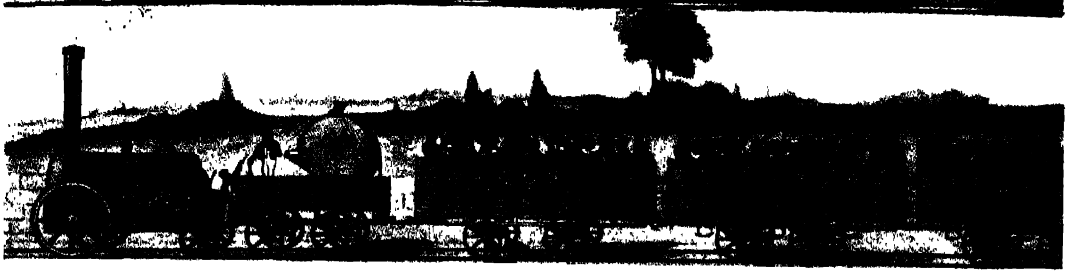


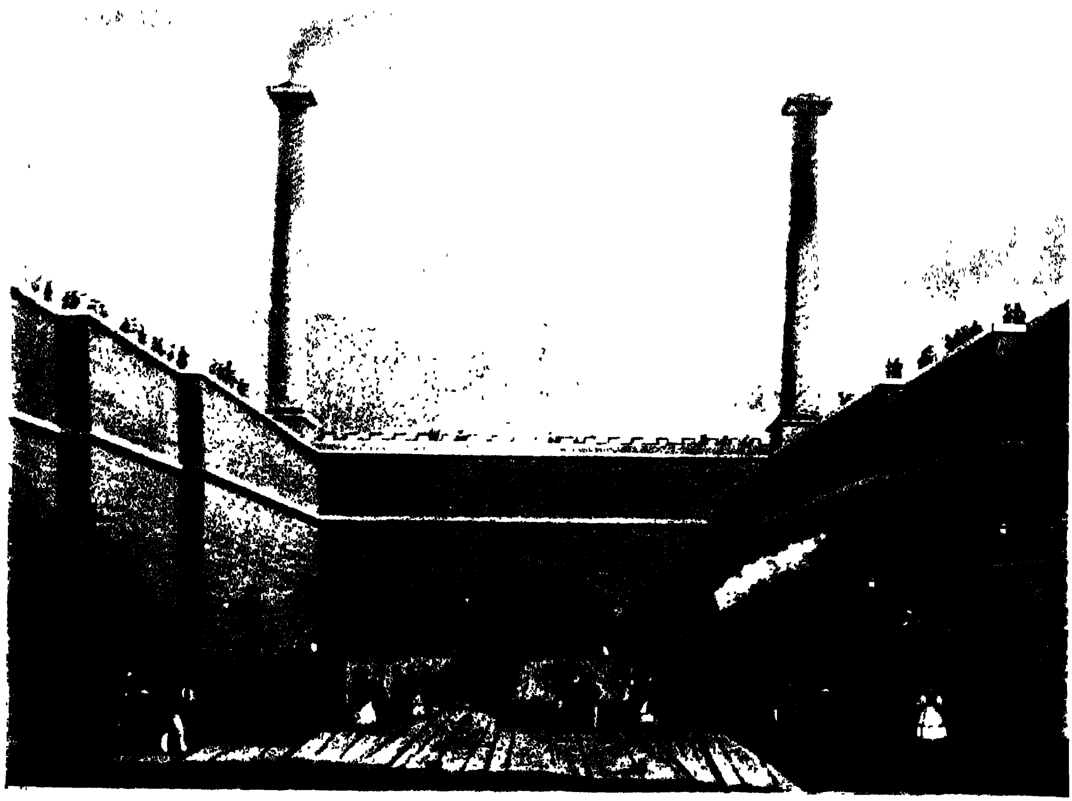
GEORGE STEPHENSON (1781-1848) built some of the first locomotives, was in charge of the construction of the Liverpool-Manchester railway, and became chief engineer of various lines.

P. Gaskell, a keen and humane observer, describes in *The Manufacturing Population of England* (1833), the life of a typical townsman of the north.

THE "CHARLOTTE DUNDAS," the first practical steam-driven vessel, built by William Symington in 1801, plied experimentally on the Forth and Clyde canal.

> Rising at or before daybreak, between four and five o'clock the year round, scarcely refreshed by his night's repose, he swallows a hasty meal or hurries to the mill without taking any food whatever. At eight o'clock, half an hour, in some instances forty minutes, are allowed for breakfast. In many cases the engine continues at work during mealtime, obliging the labourer to eat and still overlook his work. This meal is brought to the mill, and generally consists of weak tea, of course nearly cold, with a little bread ; in other instances of milk and meal porridge. After this he is incessantly engaged, not a single minute of rest or relaxation being allowed him.
>
> At twelve o'clock the engine stops, and an hour is given for dinner. The hands leave the mill and seek their homes, where this meal is usually taken. It





IN THE EARLY DAYS OF THE RAILWAY

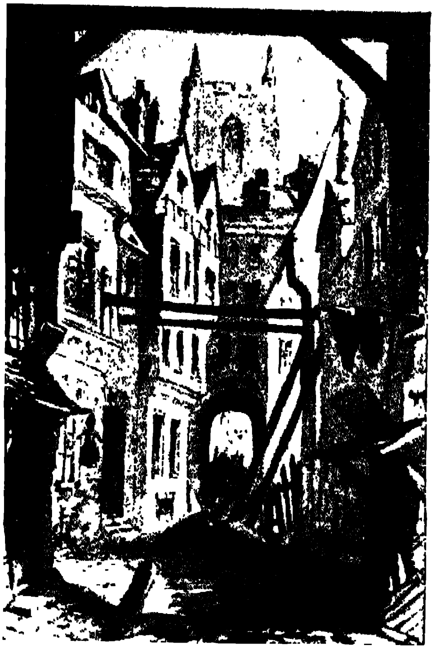
The Liverpool and Manchester line was opened in 1830, birth year of British railways. The station at Edge Hill, Liverpool, is seen above in an aquatint of 1833. At the top are first class carriages; centre, second class carriages

NEW IN THE 19th CENTURY. Early in the 19th century the horse-drawn cab (cabriole) was introduced into London from Paris. Above is a 4-wheeler (popularly called a "growler"). On the left is a 2-wheeled hansom cab such as first appeared on London streets in 1834. They were gradually displaced by motor taxicabs during the early years of the 20th century.

20th CENTURY COMFORT. Right: One of London Transport's 6,800 standard RT type 56-seat double-deck buses, which help to carry the 11½ million passengers who use London Transport's services daily Certainly comfort has been gained, but with the tremendous increase in urban traffic speed in transit has been generally reduced.

consists of potatoes boiled, very often eaten alone, sometimes with a little bacon, and sometimes with a portion of animal food. If, as often happens, the majority of the labourers reside at some distance, a great portion of the allotted time is necessarily taken up by the walk, or rather run, backwards and forwards. The meal has been imperfectly cooked, by someone left for that purpose, not unusually a mere child, or superannuated man or woman. The entire family surround the table, if they possess one, each striving which can most rapidly devour the miserable fare before them . . . As soon as this is effected, the family is again scattered. Again they are closely immured from one o'clock till eight or nine, with the exception of twenty minutes allowed for tea. This imperfect meal is almost universally taken in the mill: it consists of tea and wheaten bread, with very few exceptions. During the whole of this long period they are actively and unremittingly engaged in a crowded room and an elevated temperature, so that, when finally dismissed for the day, they are exhausted equally in body and mind.

It must be remembered that father, mother, son and daughter are alike engaged; no one capable of working is spared to make home (to which, after a day of such toil and privation, they are hastening) comfortable and desirable. No clean and tidy wife appears to welcome her husband; no smiling and affectionate mother to receive her children. All assemble there equally jaded.



"TOM-ALL-ALONE'S." One result of the Industrial Revolution was the huddling together in insanitary slums of great numbers of people. One noisome warren was "Tom-all-Alone's," described by Dickens in "Bleak House" and here pictured by "Phiz."

The homes of the unhappy "hands," continues Gaskell, were but too truly an index of the lives of their inmates.

What little furniture is found in them is of the rudest and most common sort, and very often in fragments: one or two rush-bottomed chairs, a deal table, a few stools, broken earthenware, such as dishes, teacups, etc., one or more tin kettles and pans, a few knives and forks, a piece of broken iron serving as a poker, no fender, a bedstead or not as the case may be, blankets and sheets in the strict meaning of the words unknown—their place often being made up of sacking, a heap of flocks or a bundle of straw supplying the want of a proper bedstead and feather bed; and all these cooped in a single room.

Living conditions among the poor of the new cities were appalling, even to those of the prosperous classes who managed to forget them for most of the time, and who, when they remembered it, regarded the state of affairs as divinely ordained. Whole streets were undrained, or had drains of the most primitive description, with the result that slops and refuse were discharged into the street; one convenience frequently did duty for 50 dwellings; innumerable rows of back-to-back houses were flung up, separated from one another by narrow courts, across which the inhabitants of opposite dwellings could shake hands without quitting their doorsteps. And beneath some of these hovels were cellars inhabited by an even more hopeless class of being.

The age of the machine had dawned, bringing wealth for the machine's owner, but little for its minder. So in every industrialised land there came into being the two nations spoken of by Benjamin Disraeli in *Sybil*:

Two nations; between whom there is no intercourse and no sympathy; who are as ignorant of each other's habits, thoughts, and feelings, as if they were dwellers in different zones or inhabitants of different planets; who are formed by a different breeding, are fed by a different food, are ordered by different manners, and are not governed by the same laws.

Two nations—the rich and the poor!

TOWN SLUM. The horrible system of building back-to-back houses was adopted in the 19th century in industrial areas. Together with overcrowding, this added to the economic misery.

LESSON 22

Prophets of Socialism

THE Industrial Revolution was still young when the question began to be asked: were the poverty and squalor, the overcrowded and insanitary towns, really included in the price that must be paid for vastly increased powers of production and means of transport, with their advantages of prosperity for owners, organizers, and shareholders in the system ?

Among the first to look squarely at the new industrial order and to attempt to remedy its evils was one of the most successful of the new capitalists, Robert Owen (1771-1858). He was the son of a Welsh saddler, received scarcely any education, and became a shop assistant at the age of ten. Exceptional ability and good fortune raised him at the age of 19 to the post of manager of a cotton mill in Manchester employing 500 hands.

A few years later he became part proprietor and director of the mills at New Lanark, on the Clyde, and there showed it to be possible to run a huge and highly profitable business without basing its success upon the degradation of the workers. He regarded these "unfortunately placed people," he wrote as being the creatures of ignorant and vicious circumstances, made what they were by their evil surroundings, for which society alone might be held responsible; his intention was to "supersede the inferior and bad characters, created by inferior and bad conditions, by superior and good characters, to be created by superior and good conditions."

At the time Owen was regarded as a hopeless visionary; the majority of the employing class honestly believed that providence decreed that they, the efficient and the strong, should rule the great mass of their fellows, who lacked strength of character or ability, and would in any event remain poor and miserable. Their own responsibility in the creation of circumstances which produced the recklessly prolific mass of expendable "hands" either did not occur to them or was calmly accepted as part of the process of industrial development.

Owen spent thousands of pounds on schools at New Lanark. He was one of the prime movers of the passing of the Factory Act of 1819, which prohibited the employment in cotton mills of children under nine and limited the labour of children under 16 to twelve hours a day. He has claims to be regarded as the founder of the British socialist movement, and established communistic settlements in Hampshire, Ireland, and America; all these settlements proved unsuccessful. His influence inspired 28 poor weavers, the "Rochdale Pioneers," who in 1844 opened the first co-operative store.

Socialist Beginnings

Despite Owen's enthusiastic advocacy, socialism—a concept which is defined in hundreds of ways, but which can be generally regarded as community ownership (instead of individual ownership) of the means of economic production—made little headway in Britain, although the enfranchisement of part of the middle class in 1832 and publicity given to scandalous conditions in the towns and factories led to much social reform by way of legislation.

PRACTICAL PHILANTHROPIST. Robert Owen's observations of the factory system and the sufferings it entailed upon workers, led him to make an experiment at the New Lanark mills, where his employees worked under favourable conditions.

Elsewhere theorists were more regarded. In France, for instance, the eccentric but high-minded Count Saint-Simon (1760-1825) claimed to be the father of socialism; he believed in the maintenance of private property, and in his dream of an ideal state he saw producers of every grade working hand in hand with the government for the common good. François M. C. Fourier (1772-1837), a commercial traveller of bourgeois stock, amused himself and others with the planning, like Owen, of socialist communities in a capitalist world. Very few early socialist leaders seem to have sprung from the "proletariat," probably because proletarians were usually worked too hard, and fed and housed too badly, to have many ideas beyond what was considered their station in life.

Other French socialistic thinkers include P. J. Proudhon (1809–65), who in 1840 published *Qu'est-ce que la Propriété ?*, in which he roundly declared that "Property is theft," having in mind the property of the "idle rich," who exacted rent and interest from active producers. Louis Blanc (1813–82), who believed most of the evils of society were due to competition, urged the establishment of social workshops in which men would be assured of employment at a fair wage and under decent conditions of labour. Auguste Comte (1798–1857) founded the "Religion of Humanity," or Positivism, in which no deity beyond the skies is worshipped but humanity itself is held in reverence.

KARL MARX. Chief exponent of the materialist conception of history, he published Vol. 1 of his work "Das Kapital" in 1867. He sought to overthrow capitalism by development of class consciousness among the proletariat.

In Germany the first great socialist leader was Ferdinand Lassalle (1825–64), a cultured and wealthy middle-class Jew with a great gift of platform oratory, who for some years was very popular with the working class, and founded the Universal German Working Men's Association, which after his death became the Social Democratic party. Lassalle advocated, in particular, universal suffrage and a kind of state socialism. He was concerned with organization of socialism in Germany when he died— mortally wounded in a duel arising out of a love affair.

Karl Marx

The greatest and most influential of all the socialist prophets of Germany was Karl Marx (1818–83), born at Treves of well-to-do Jewish parents and brought up to the law. Early in life he adopted revolutionary views. After the German revolution of 1848 had fizzled out, he came to England and spent much of the rest of his life studying in the reading room of the British Museum. For some time his only income was the 20 shillings per article he received as London correspondent of a New York paper. He lived in rooms at Camberwell with his wife and little children, and once the landlord sent two constables to attach for debt every stick of their possessions, even the baby's cradle, the children's toys, and the bedclothes. Marx was suspected of being a burglar when he offered for pawn some of his wife's heirloom silver ; and when one of their daughters died, Mrs. Marx had to borrow money from a French refugee to pay for the coffin. To the end of his life Marx was poor. His work received scant recognition, especially in England. Had it not been for financial and moral support from his life-long friend, Friedrich Engels, who had inherited from his father a share in a cotton-spinner's business in Manchester, Marx might have died and left not even a name behind him.

Communism

Marx was the founder of "scientific" socialism as opposed to the utopian, sentimental, or voluntary variety preached by Owen and the French theorists. Non-Marxist economic science, typified in the work of Adam Smith (1723–90) and Ricardo (1772–1823), had developed under an economic system only partly capitalist, i.e. not entirely disengaged from its feudal basis, and better described as the "mercantile" system. Elaborate laws and regulations governed both trade and industry, and Adam Smith advised that they be swept away, to allow capitalists to buy the labour of non-capitalists as they pleased.

This process would, it was predicted, enormously increase the wealth of nations ; as it evolved, it enormously increased the wealth of capitalists, which was frequently assumed to be the same thing. Marx had noticed that it was not the same thing ; "just as non-Marxian economics are a criticism of pre-capitalist conditions and a demand for capitalism, so Marxist economics are a criticism of capitalism and a demand for socialism." The first exposition of the new gospel was contained in the communist manifesto (to Marx communism and socialism were almost identical) issued by Marx and Engels in 1847. The manifesto contains a searching analysis of economic evolution and of the part played in it by the middle class, the *bourgeoisie*. It concludes with words which have found an echo in many a rebellious worker's heart :

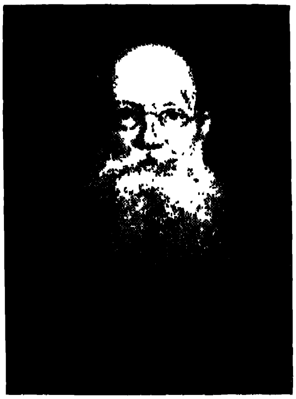
> Let the ruling classes tremble at a communistic revolution. The proletarians have nothing to lose but their chains. They have a world to win. Working men of all countries, unite !

Twenty years later appeared the first volume of *Das Kapital*, by Marx, sometimes described as the socialist's bible, in which, interspersed with abstruse reasoning on surplus value and other economic topics, is many a deeply interesting allusion to the prevailing conditions in English industry and agriculture. According to

Engels, Marx's greatest contribution to economic thought was his discovery of

the evolutionary law of human history—the simple fact, hitherto hidden under ideological overgrowths, that above all things men must eat, drink, dress, and find shelter before they can give themselves to politics, science, art, religion, or anything else

The claim has often been disputed, especially by those with unquestioned access to food, clothing, and shelter; but at least it can be said that Marx, more than any other man, won converts to the so-called materialist conception, the economic interpretation, of history. He was no ordinary dreamer. With a religious dogmatism born of absolute certainty, he declared what he believed *would inevitably come to pass* - the concentration of capital in fewer and fewer hands; the final conflict between a handful of capitalist expropriators on the one hand and millions of class-conscious property-less proletarians on the other; the ensuing "dictatorship of the proletariat" to endure until classes have been abolished and a society of free and equal citizens has been created. Marx's romanticism expressed itself in belief in the possibility of a proletarian unity transcending national frontiers, and in the mystical future emergence of a classless state in conditions hostile to such an emergence.



KROPOTKIN won distinction as a geographer before developing his theory of an anarchistic social order based on "mutual aid" instead of the Darwinian "struggle for existence."

Bakunin and Kropotkin

Opposed to Marx was the Russian anarchist Mikhail Bakunin (1814 76). Though he was of aristocratic birth and a former officer in the Imperial Guard, Bakunin was so revolted by what he saw of tsarist government in Poland that he adopted extreme anarchistic views, and devoted his efforts to planning the overthrow of the state by armed insurrection. Marx seems usually to have envisaged peaceful political action. The consequent clash of views and personalities resulted in a cleavage in the socialist ranks.

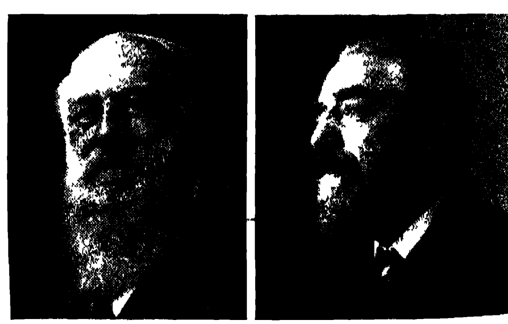
Another anarchist was the geographer prince Peter Kropotkin (1842 1921), another man of noble Russian birth, and like Bakunin for years a political prisoner. Kropotkin's anarchism was based on "Mutual Aid"—his best-known book—rather than on military risings and dictatorship, and he envisaged a world where men lived together as free as the absence of governmental and legal restrictions could make them.

On the whole, Continental socialists followed Marx, and before the First World War (1914-18) Social Democratic parties were established in many lands. One such party was founded in England by H. M. Hyndman (1842-1921), in 1881; and the Socialist League, with which William Morris (1834-96), the painter-poet, was connected, also professed the Marxist gospel. Morris was drawn into politics by the sordid spectacle of working-class life.

The Fabian Method

The Fabian Society, founded in 1883 by G. Bernard Shaw, Sidney Webb (later Lord Passfield), Sydney (later Lord) Olivier, and other intellectual leaders of the day, developed its policy in accordance with its name, borrowed from the Roman general, Fabius Cunctator (the "Delayer"), who never attacked Hannibal direct but nibbled constantly at his flanks. Socialism by peaceful permeation was the Fabian method, and the statute book of the next 50 years bears witness to its success.

These distinguished men led socialist movements at a time when the proletariat could hardly be expected to throw up national leaders from its own ranks. But the real missionaries of the socialist gospel were the humble workers who spent their days in dockland or factory or mine, and their evenings on soap-box platforms at street-corners or in parks. Night after night they thundered denunciation, proclaimed the "class war," and prophesied the coming of the revolution. The issue seemed delightfully simple: rich versus poor. The result seemed fairly certain: a proletarian triumph. So "Workers of the world, unite: you have nothing to lose but your chains!"



MARXIST AND FABIAN. H. M. Hyndman (left) founded in 1881 the Social Democratic Federation. Lord Passfield (right), formerly Sidney Webb, was one of the earliest members of the Fabian Society and with his wife was a mainstay of the growing Labour movement.

But socialist government lay far in the future; the factory-hands had not yet to commit themselves to much more than an occasional cheer or boo. In those times the missionary's was uphill work; a few listeners were converted, but many more heard and misunderstood, or would not understand, or they speedily forgot. It has been written of William Morris that

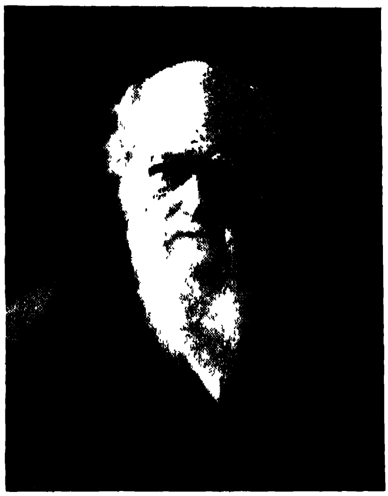
he was, he at last perceived, too simple to be understood. He discovered that the mass of men love sound and fury and only with pain and suspicion follow the most pellucid reason. The British workman, moreover, was inert . . . when it came to the point the worker had no stomach for resistance; his declared hatred of the upper classes was mere wind . . . given half a chance, he would gladly join this same 'blood-sucking' group . . sceptical and cold-blooded, they (i.e. the workers) were middle-class at heart.

Generalisation of this kind is often very inaccurate, and as trade union organization grew, the "stomach of resistance" developed justifiable strength; but the British working-man's "inertia" (of which both his friends and his economic enemies were frequently to complain) may also have partly protected him against the latest exploiter of all, the dervish of communist theory at home and abroad.

LESSON 23

Evolution and Social Thought

The changes in industry and commerce, transport and agriculture, that together make up the Industrial Revolution, were followed by a revolution in men's thinking, in the way they looked at themselves, their world, and the universe. The application of mechanical power to manufacture and locomotion made it impossible to maintain conditions that had prevailed in the days before steam. In the same way, after the idea of evolution had become current coin, it was impossible for intelligent people to continue to think that man was something quite apart from the animal creation, a something for whom the world was a specially designed stage, for whom nature was a generally subservient servant.



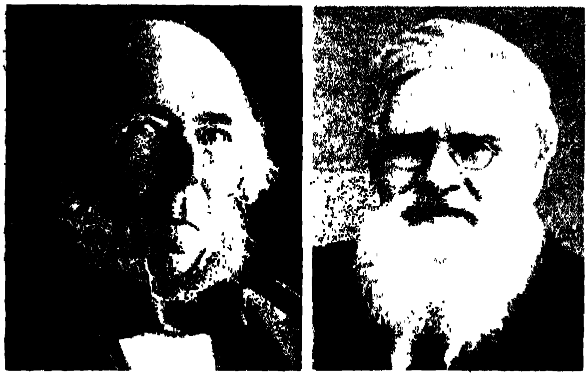
CHARLES DARWIN began his transformation of the scientific outlook of the 19th century by the publication of "The Origin of Species," 1859, and completed with "The Descent of Man" and "Selection in Relation to Sex," in 1871.

Early Evolutionists

Evolution was not, of course, a 19th-century product. Some of the early Greek philosophers, when speculating on the origin of things, envisaged a creation by ordered stages instead of by catastrophic process; and the conception, though in suspense during the medieval twilight, was revived with the Renaissance. The discoveries of Copernicus and Galileo, Kepler and Newton, militated against the theory of an unchanging universe; and towards the end of the 18th century distinguished naturalists —Buffon, Lamarck, and Erasmus Darwin—were driven to postulate something approaching the evolutionary hypothesis.

It was left to Erasmus Darwin's grandson to erect a factual basis for the theory, to suggest methods of evolutionary progress, to become the populariser of the evolutionary idea. Charles Darwin (1809–1882) found the first material for his life-work as naturalist in *H.M.S. Beagle* on a five-year voyage of scientific discovery in the South Seas. Having inherited ample means, he lived thenceforth the life of a country gentleman at Downe in Kent. Partly an invalid, he accomplished a vast amount of research in intervals of comparative good health. Very early in his career he became interested in the problem of the origin of species. At length, in 1859, he gave to the world in an epoch-making book with that title his theories of natural and sexual selection—the preservation and handing-on of variations tending to aid their possessors in the struggle for existence, and of those useful in obtaining a mate by force or by attraction.

The fittest survive, he maintained—the "fittest" not necessarily meaning the "highest" or the "best" but merely those creatures most suited to a particular environment at a particular time—a fact which some of his disciples, in their anxiety to prove that "might is right," tended conveniently to forget. Twelve years later, in his book *The Descent of Man*, Darwin claimed that man himself is no exception to the rule—that he, too, is the product of change, of an age-long process of variation—and that he shares a common ancestor with the ape and baboon.



GREAT EVOLUTIONISTS. Herbert Spencer (left) devoted his life to an attempt at formulating a philosophic basis for the progressive science of the day. Alfred Russel Wallace (right) put forward the theory of natural selection, an hypothesis of evolution by natural selection, simultaneously with Darwin.

Soon after the publication of *The Origin of Species* Darwin was furiously assailed by some of his fellow-countrymen as one who dared to set a puny human intellect against the word of God. Did not the Bible declare that the fish of the sea and the fowls of the air, the great beasts, the herbs and trees, were made by the Divine Artificer in six days of creation ? Did not the same unimpeachable authority teach that the first man was formed from the dust of the earth and the first woman from a rib taken from his sleeping body ? Had this student of earthworms the audacity to declare that the animals walking the continents in his lifetime were not as they proceeded from the primal workbox but had been altered, adapted, *improved* ? Was it not a particularly offensive blasphemy to claim that *men* were of animal stock, belonging to the same family as the monkeys ?

Huxley's Reply

In 1860 Darwin's theories came up for discussion at a meeting at Oxford of the British Association. Professor T. H. Huxley (1825–95) was there to uphold them ; Bishop Wilberforce led the attack, and " in a light, scoffing tone, florid and fluent," assured his hearers that " there was nothing in the idea of evolution ; rock-pigeons were what rock-pigeons had always been." Then, turning to his antagonist with a smiling insolence, he begged to know, was it through his grandfather or his grandmother that he claimed his descent from a monkey ?

Huxley's reply is historic. With the aside to a friend, " The Lord hath delivered him into mine hands," he proceeded :

> I asserted—and I repeat—that a man has no reason to be ashamed of having an ape for his grandfather. If there were an ancestor whom I should feel shame in recalling it would rather be a *man*—a man of restless and versatile intellect—who, not content with success in his own sphere of activity, plunges into scientific questions with which he has no real acquaintance, only to obscure them by an aimless rhetoric and to distract the attention of his hearers from the real point at issue by eloquent digressions and skilled appeals to religious prejudice.

That episode was the beginning of a battle that raged for years and inspired much bitter argument. A typical reaction at the time when those theories were new was that of Benjamin Disraeli. At Oxford in 1864 he obscured the point at issue as follows : " What is the question now placed before society with a glib assurance the most astounding ? The question is this : Is a man an ape or an angel ? I, my lord, I am on the side of the angels . .

Darwin's Books Banned

Very soon some of what Darwin called the old fogeys at Cambridge " began to express impartiality, always a sign of disintegration. The Master of Trinity held his judgment, and to help his colleagues and pupils to do the same, he took the wise precaution of not allowing Mr. Darwin's books in the college library."

APOSTLE OF DARWINISM. Huxley was among the mid-Victorian scientists who combined with scientific achievements the power to explain with complete lucidity.

Painting by John Collier, Nat. Port. Gall.

The echoes of anti-Darwinian fury were long in dying away. In 1923 the state of Ohio, U.S.A., passed a law forbidding the teaching of "any theory that denies the story of the Divine creation of man as taught in the bible." A teacher of biology at Dayton, Ohio, challenged this law, and was prosecuted and later fined for teaching the theory of evolution to a schoolboy of 14.

Shortly before Darwin's pronouncement Herbert Spencer (1820–1903), one of the distinguished company of English scholars who never studied at a university, began to apply the doctrine of evolution to the consideration of society as a whole. In 1860 he published the plan of "System of Synthetic Philosophy," in which the principle was applied to biology, psychology, sociology, and ethics. Though styled a philosophy, this system had little to do with ultimate problems that make up most philosophical systems; rather it was concerned with things known, with the generalisations of science. Philosophy as generally understood was dealt with in a hundred pages under the significant title of *The Unknowable*.

Another distinguished evolutionist was Alfred Russel Wallace (1823–1913), who, after some years of naturalist exploration in the Amazon region and the Malay Archipelago, propounded a theory of natural selection so extraordinarily similar to that of Darwin that the two collaborated in a paper on the subject for the Linnaean Society.

Historians proceeded to use the key of evolution to turn the locks of their subject. Instead of being regarded as a series of individual events, as the record of doings of such men as those whom Spencer contemptuously styled Frederick the Greedy and Napoleon the Treacherous, history began to be revealed as a never-ending process whose laws were to be discerned almost as clearly as those governing the movements of the planets across the sky. No longer dated from Creation Day in 4004 B.C., history and pre-history were realized as developments through many millions of years. The more open-minded of the educated public quickly incorporated these revolutionary new conceptions into the body of generally accepted beliefs. To-day the *principle* of evolution is held by most people capable of forming any opinion on such a subject; the *method* is still the subject of discussion—and of wonder!

LESSON 24

The White Man in the Antipodes

The white man's occupation of parts of America was followed by his descent upon Australia and New Zealand. The first inhabitants of Australia, at an unknown period, reached the island continent in boats of bark. Successive expeditions or invasions passed across the country to its southern coasts. Only in the 16th century did European geographers begin to suspect the existence of this land mass. The Dutch made it known for a certainty in the next century. In 1688 its shores were first glimpsed by an Englishman, William Dampier.

CAPTAIN COOK (1728–79) in the course of his three famous voyages visited Australia, New Zealand, and the South Seas. He was murdered by savages in the Sandwich Islands.
N. Dance, Greenwich Hospital

Cook's Discoveries

In 1770 Captain Cook's *Endeavour* dropped anchor in Botany Bay, and the territory was formally annexed to the British crown under the name of New South Wales. Cook wrote in his Journal:

> The country is woody, low and flat as far in as we could see, and I believe that the soil is in general sandy . . . on the sand and mudbanks are oysters, mussels, cockles, etc., which I believe are the chief support of the inhabitants, who go into shoal water with their little canoes and peck them out of the sand and mud with their hands, and sometimes roast and eat them in the canoe . . . The natives do not appear to be numerous, neither do they seem to live in large bodies, but dispersed in small parties along by the waterside. Those I saw were about as tall as Europeans, of a very dark brown colour, but not black, nor had they woolly, frizzled hair, but black and lank like ours. No sort of clothing or ornaments were ever seen by any of us upon any one of them, or in or about any of their huts; from which I conclude that they never wear any. Some that we saw had their faces and bodies painted with a sort of white paint or pigment.

Their homes were mean, small hovels, made of sticks, bark, and grass; their canoes, too, were made of bark and held but two persons; their tools were sticks and stones, shells and bones.

As Cook saw them, the aborigines had no doubt lived for long ages. They moved from water-hole to water-hole, used flint-headed spears, clubs, and boomerangs to hunt kangaroo; ate birds and their eggs, fish, frogs, snakes; danced with hungry joy when a rotting whale was thrown ashore by a stormy sea, cut their way through its blubber with their hatchets, and wallowed in its corpse for days. ("There is no sight in the world more revolting," wrote one of the early explorers, "than to see a young and gracefully formed native girl stepping out of the carcass of a putrid whale.") They built their frail shelters of twigs and bark, sufficient for a day; sailed the rivers and hugged the coasts in their rude canoes, or on logs or rafts.

Century after century the lubras (native women) bore their children with careless ease, stepping aside for an hour or two, then renewing the march with the new-born babe at breast. Boys became men by initiatory rite ; and girls were incised, kneeling between an old woman's knees while their backs were scored by shell or flint with long, deep gashes. Men with fantastically painted bodies danced and masqueraded at tribal corrobborees. The dead were buried in shallow, stone-covered graves, or were exposed until mummified on tree-platforms, adding a macabre touch to the landscape. And to-day, despite the raising on Australian soil of an imposing new civilization, the aboriginal roams the arid heart of the continent much as his forefathers roamed before him.

Botany Bay

The first use of the newly annexed land was as a dump for rejects of British society—criminals by the strict code of the time, although many of them were guilty of crimes which to-day might have earned them a "caution." In 1787 nine transports, escorted by two men-of-war, conveyed 828 convicts, of whom 300 were women, to Botany Bay, where they arrived in January of the following year.

The first settlement was made on the well-timbered shores of Sydney Cove. Ground was cleared, tents were run up, huts and barracks of clay and thatch were erected. Governor Phillip read his royal commission, warned those who were still criminally disposed that they might expect no mercy if they were detected in fresh crimes, and sternly denounced the very general immorality. In conclusion, he strongly recommended marriage, and promised assistance to those who should enter into that state. During the ensuing week 14 couples were wedded, but some, not receiving the little comforts and privileges they had been led to expect, soon applied (without success) to be restored to single blessedness.

For many years the criminal population of Britain was emptied into the colony ; from time to time a free farmer or trader was induced to make the voyage. Most of the convicts were "assigned" to government officials and free settlers as unpaid hands. The more refractory were set to work making roads under military supervision, incorporated in the dreaded "chain gangs," whose members were fettered and lashed at the slightest provocation, or, worse still, sent to one or other of the penal settlements that were established in the colony.

Few convicts ever returned to Europe ; their lot as assigned servants was often reasonably pleasant, and after they had served their time or were released on ticket-of-leave, they had opportunities of advancement far beyond those available in the home country. Where nearly everyone was, or had been, a convict, the fact involved no disgrace and little inconvenience. Some ex-convicts carved out careers bringing them incomes of ten, twenty, even forty thousand pounds a year.

Wool Industry Begins

It was not very long before New South Wales became more than a penal settlement partly populated by prostitutes and jail-birds. In 1794 John Macarthur, who had accompanied Captain Phillip from England and was given a commission in the colony's defence corps and 200 acres at Parramatta, began to experiment in the rearing of sheep, and laid the foundation of what was to be Australia's greatest industry.

Early in the 19th century a gap was discovered in the Blue Mountains west of Sydney. A host

SYDNEY IN 1805. Founded in 1788 by Governor Phillip as a convict settlement, Sydney was named after Lord Sydney, colonial secretary at the time the territory became a British possession. Its position favoured its rapid expansion, and by the end of the 18th century it had a population of free settlers numbering about 5,000. Above is a view of the southern portion of the town and the mouth of the Parramatta river as they appeared in 1805.

From Peron et Freycinet, "Voyages aux Terres Australes"

GOLD-RUSH. In 1851 gold was discovered in New South Wales, and at once there began a rush of immigrants. This picture from "The Illustrated London News" of July 3, 1852, shows diggers at work in the Forest Creek region of Mount Alexander, Port Phillip, watched by two native police, members of a corps established not twelve months earlier.

of eager sheep-rearers soon found the rich grazing-lands beyond. In the 1850s the discovery of gold in the river-beds of Victoria led to another rush of population and the founding of numerous townships, centres of lawless, vigorous life. For years Australia continued to receive contingents of convicts, until in 1867 the colonists' protests were heeded and the transportation of criminals ceased.

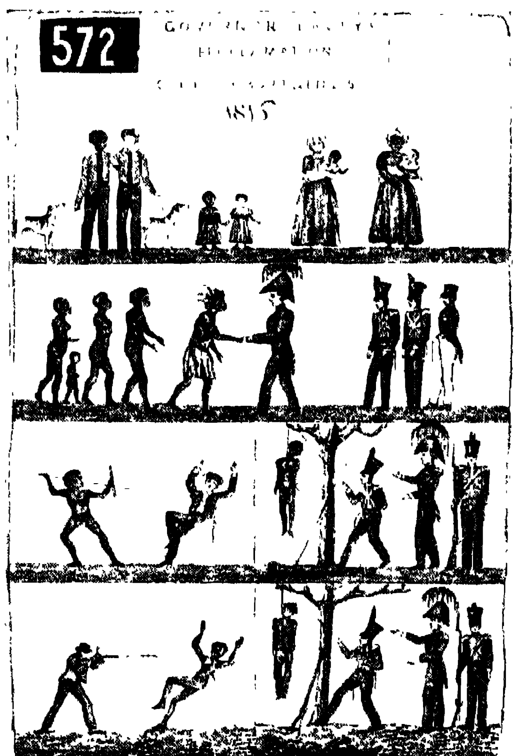
Settlement of Western Australia began in 1829, and within the next 30 years Victoria, South Australia, and Queensland were carved out of what was originally New South Wales. The home government allowed the new colonies to draft their own constitutions. Until the end of the 19th century each of the new states was practically independent; only growing fear of Japan, and the appearance in the Pacific of Germany and other rival colonising powers, induced the states to federate and try to become a nation.

Annexation of New Zealand

New Zealand, 1,200 miles south-east from Sydney, was discovered by the Dutch navigator Tasman in 1642, and annexed to Britain by Captain Cook in 1769. The home government, reluctant to assume responsibility for further territory, disavowed Cook's action; but in 1840 the islands were formally annexed, partly to prevent their appropriation by France, partly because of increasing friction between the high-spirited natives, the Maoris, and the white population. Frequent wars with these natives during the next few decades were not wars of extermination such as the white man often waged in his colonial ventures; for generations New Zealand has possessed in the Maoris a body of useful citizens.

The Commonwealth of Australia was inaugurated in 1901. Now, more than half a century later, the population is about nine million, of whom the vast majority are white; aborigines, who are now encouraged to maintain their tribal cohesion, number something under 80,000, and there are a few thousands of Chinese, Japanese, Indians, and other races, together with half-castes. The constituent states retain considerable administrative power, but the great part played by the Commonwealth in the two world wars, and the coming of air traffic, have combined to lessen the differences of interest between them, and between the elements within each state (nine-tenths of Australians live in cities, but there are sheep-farms the size of small English counties).

Basing their claim to keep Australia "white" on the fact that Asian peoples took no interest in the island continent until Europeans had



GOVERNOR DAVEY'S PROCLAMATION to the aborigines of Tasmania in 1816 gave the natives a pictorial statement of the policy of friendship that he intended to institute between blacks and whites, based on equal justice to both races.

From Dilke, "Greater Britain," 1868

found its harbours and begun to develop its great resources, the Australians mean to maintain their western civilization at its high standard—the south-eastern and eastern coastal country has been described as " 3,000 miles of suburbia in the sun "—and even the vast central semi-desert and empty north-western coastline have lately been put to use. Inland from Adelaide the rocket-range of Woomera is the testing-ground for joint British and Australian work in one essential scientific development of the age ; the name " woomera " was that recorded by Captain Cook as given to the throwing-stick with which the aboriginal increased his power to hurl a spear. Right across the continent, at Monte Bello Island not far from the North West Cape, the first British atomic bomb was exploded in 1952, and the first British hydrogen bomb in 1956.

Australia and New Zealand are British communities whose loyalty to the Crown, to their partners in the Commonwealth of Nations, and to democratic ideals has been proven time and again.

LESSON 25

Black and White in Africa

In Victorian days a British name for Africa was the " Dark Continent," because much of the interior was a geographical mystery. To-day there are still areas of a darkness chiefly political ; Africa is the scene of a great diversity of social systems and of a number of different experiments in the relations of white and coloured peoples.

What is probably the earliest discernible civilization grew up in the Nile valley ; and no matter what concepts the pyramids were meant to express, they now chiefly exhibit a gesture of iron autocracy and the antiquity of the institution of slavery. The temples, tombs, and monuments of the dynastic centuries present even in ruin a formidable reminder of ancient power and magnificence. Aside from Egypt and the other Mediterranean lands, the chief monumental remains of early African civilization are the groups of stone strongholds, often supposed to be of Bantu origin, at Great Zimbabwe in Southern Rhodesia ; the date of their building is variously assigned between the 3rd and 10th centuries A.D.

The Egyptian was for many centuries the only considerable African civilization. Circumscribed by desert and sea, it exhibited long phases of expansion and decline, and survived degrees of conquest by Hyksos, Persians, Macedonian-Greeks, Romans, and Saracens. Extinguished as a world power, the country was later controlled by Turks, French, and British, becoming an independent Muslim kingdom in 1922 and in 1953 a republic.

Ethiopian Life

Next most ancient is the Ethiopian or Abyssinian dominion at the other end of the Red Sea ; traditionally the kingdom of Sheba whose queen visited King Solomon, it became Christian in the 4th century. Long surrounded by Muslim peoples, the country was dimly apprehended by medieval Europe as the largely fanciful kingdom of Prester John. Conquered by Italian bombs and poison gas in 1935 (a historic revenge for the defeat of an Italian expedition in 1896), but never entirely occupied, the country was liberated in 1941. The emperor, Haile Selassie, set himself to modernise various aspects of Ethiopian life without interfering too much with the agricultural and tribal economy of a population of mixed African races and religion chiefly Christian and Muslim

The other countries of the north coast of Africa were first civilized from across the Mediterranean. Behind the urban and agricultural coastal belt, with its immemorial mingling of races, stretches the desert with its oases, supporting a small population of Berber tribes—Mediterranean types, sometimes blond—mixed with Arabs. Some are nomads ; some live in mountain caves or pit dwellings.

Independence Regained

Libya, an independent African kingdom since 1951, was for some years an Italian colony, and its Europeans are mostly Italians, the Muslim natives being one-third Negroes : there are also many Jews. Ruins of Greek and Roman colonial cities attest the importance of the fertile coastal areas until the Muslim invasion During a long period of nominal Turkish rule the town of Tripoli became a nest of pirates, whose depredation drew upon it, about 1800, United States naval bombardments.

Tunisia, a French protectorate from 1881 to 1956 and now an independent republic, is the country once ruled by the great city of Carthage, after whose fall it was re-colonised by the Romans, and conquered by Vandals and Byzantine Greeks before being overrun by the Muslim advance. Algeria is a department of France. Morocco, under its sultan, was another country to regain its independence in 1956. It was divided for most of the 20th century into three zones—French, Spanish, and International—though retaining nominal independence. In all these countries, as in Egypt, the dominant force of the 1950s was not so much a spirit of nationalism as one of " Africanism " seeking freedom from European control or even European association.

The vast Sahara Desert includes the hinterlands of most of the settled countries from the Atlantic to the Nile ; this is not a consistently sandy waste, but the dried-up wreck of a once fertile region. The sandy areas enclose many stony tracts and salt deposits. Fertile oases allow caravan routes to be maintained, and parts of the region, especially north of the Niger, can sustain herds of cattle. There is a small nomad population. Much of the Sahara is under French control, and districts formerly regarded as sterile are being increasingly cultivated. Extensive surveys, and developments of air routes, are steadily reducing the intractable areas and nature of the wilderness.

At the eastern margin of the Sahara the area established in 1899 as the Anglo-Egyptian Sudan has emerged into nationhood. The first all-Sudanese government was formed in 1954 ; "Sudanisation" of the administration was complete by the end of that year. Like almost every other country in the African continent, the Sudan is a composite area ; much of its population is semi-nomadic, Muslim in the north and pagan in the south.

The other side of the desert occupies the western bulge of the continent, the coastline of which was the first part to be explored by the 15th century Portuguese. The early names of the coastlands reveal the motives of those hardy voyagers ; on the Grain Coast (the "grain" was a kind of pepper), the Ivory Coast, the Gold Coast, the Slave Coast, the Negroes first felt the full impact of the white man's power.

Negro Republic of Liberia

On what was the Grain Coast lies now the independent Negro republic of Liberia, established in 1847 by the efforts of American philanthropic societies to make a country for freed slaves—a high-minded, if tardy, gesture of acknowledgement of the shocking history of those coasts in the intervening centuries. The American-Liberian element naturally almost monopolises the administration ; together with the civilized and more or less Christian coast tribes, it numbers less than a tenth of the population, which includes both Muslims and pagans. Development of the country's resources, such as rubber, is mostly in the hands of American companies.

Before the Europeans arrived there, this part of Africa—the broad belt of grassland and scrub called the Western Sudan, where a diversity of peoples were united by Muslim faith and the rule of conquering Moors—was held by cattle and sheep herders, its market towns the home of craftsmen in gold and ivory and leather, and the southern terminal of Saharan caravans. In 1324 the emperor of a country on the middle Niger made a pilgrimage to Mecca with 80 camels loaded with gold. In the south-east of Nigeria the 16th century Benin culture produced magnificent bronzes and ivories ; but these civilizations collapsed before or when the slave traders moved in—Europeans from the sea, Arabs from the north and east. On the east coast, Roman coins and Chinese porcelain have been found as far south as Zanzibar. There again, Muslim states were established in medieval times.

In this way the rest of the world began to "develop" Negro Africa. The Negro peoples occupied the whole of the more open equatorial and sub-equatorial territory, living in populous villages and towns, wearing aprons of skins or cotton, loin-cloths of bark, and fibre skirts. They chipped and filed their teeth, distorted their lips and ears with wood and metal plugs, pierced their noses, painted and tattooed and scarred their bodies. They hunted antelope and elephant, speared and netted fish, raised goats and fowls, cultivated patches of corn with digging-stick and hoe.

Witchcraft

Their religious beliefs were and are a tangle of magic and taboos, putting them in the shadow of priests and witch-doctors, whose powers of suggestion and healing are sometimes remarkable, but whose interest it often is to maintain among their tribes an ignorance profitable to themselves. Witchcraft (in Western Africa famous as "juju") can still be oppressive and deadly, and ritual murders are not unknown. A characteristic of many parts of Equatorial Africa is communication by drum-signals.

Besides the Negroes, pygmy tribes inhabit the central jungles of Africa, such as those of the Belgian Congo. Much farther to the south the bushmen, yellow-skinned hunters, ignorant of agriculture, roamed the country of the Kalahari desert. There, too, were the nomad Hottentots, also great hunters, whose women were sometimes so enormously corpulent and heavy-buttocked as to recall the Cro-Magnon statuettes. From the Zambezi to the south of the continent the Bantu and Kaffir tribes, of which the finest physical specimens were the Zulus, possessed the best of the grazing lands and lived in settled kraals amid crops tended by their women.

The Slave Trade

Central African Negroes suffered most from the slave trade. The Portuguese began the capture of natives for shipment to the New World ; the English were quick to follow their example. Sir John Hawkins, of Armada fame, was the first Englishman to run a human cargo to the American plantations ; that was in 1562. Two years later he fitted out a larger expedition, and was so successful that on his return he was knighted by the queen (a shareholder in the venture), and took for his crest, appropriately

FREEING THE SLAVES. In 1833 a bill providing for the emancipation of the slaves in the British colonies was passed into law. Slavery was to cease on August 1, 1834. This picture expresses the jubilation of the liberated Negroes.
From Madden, "West Indies," 1833

enough, a manacled Negro. On this second occasion his flagship was the Jesus ; probably no one saw anything ironical in this.

Between 1680 and 1700 the English raiders stole from Africa about 300,000 Negroes ; the most profitable period came after 1713, in which year Spain was compelled by treaty to grant to Britain the sole right of supplying slaves to the Spanish colonies for 30 years. The clause covering this contract was one of the few provisions received in England with general satisfaction ; a special Te Deum, composed by Handel, was sung in the churches in honour of a treaty so promising to business-men. It was stipulated that 4,800 Negroes should be imported into Spanish America every year ; the British government protected the monopoly until 1750, when Spain paid £100,000 for its abandonment.

Every year thousands of slaves were sold to the British colonists in the West Indies and North America. It has been estimated that during the century ending in 1776 no less than three million Negroes were imported by the English alone into the English, Spanish, and French colonies. To that figure must be added at least a quarter of a million who died during the Atlantic passage.

The infamous Barbary corsairs (Berbers, Moors, and a scum of renegade Europeans) were pirates first and slavers incidentally, usually holding their captives to ransom, but from the 15th to the 18th century they added a grim complication to relations between Europe and Africa.

In Britain the public conscience was eventually sufficiently aroused to secure abolition first of the slave trade (1807) and then of slavery in British dominions (1833). For another thirty years slavery continued in the United States, to be ended there by one of the bloodiest civil wars in history. Meanwhile the Sudan remained as a reservoir of slaves for the Turkish, Egyptian, and Persian markets ; the Arab slavers continued to ravage that side of the continent, checked by such efforts as those of General Gordon on behalf of the Egyptian government in the 1870s, but not virtually abolished until the partition of Africa between the European powers at the end of the century.

Fantastic Tyranny

There was plenty of fantastic tyranny of black rulers over black peoples. When the British naval authorities turned to suppression of the slave trade, such native kings as those of Dahomey, the Slave Coast country *par excellence*, had become immensely rich by organizing big slave-hunts themselves. And in the far south, about 1800, Chaka thinned the prosperous cattle-herding tribes from the Cape to the Limpopo in a series of wars of extermination in which he seemed as careless of the lives of his own warriors as of those of the enemy.

The Matabele people owed its origin to one of Chaka's armies which failed to attain its objective. The general, Moselikatse, pointed out to his men that if they returned to Zululand he and they would all be killed. They agreed with him that it would be more sensible to commandeer new wives from the surrounding tribes and make a home where they were, near the Zambezi. Under Chaka's successors the Zulus encountered the Cape Dutch.

British Explorers

During the 19th century British explorers Mungo Park, Speke, Grant, Burton, Livingstone, Stanley (who was born in Wales, became an American, and recovered British nationality) —traversed the continent, and discovered or rediscovered the course of the Niger, the sources of the Nile, the great lakes, and the Congo basin. Livingstone did more than any other man to alter the European attitude to Africa and its peoples.

When Livingstone had been out of touch with civilization for some years, Stanley was sent to find him ; after Livingstone's death, Stanley became in a sense his successor as an

interpreter of African affairs, being employed by Leopold II, King of the Belgians, to help found the Congo Free State, which was later the scene of heavy fighting to break the power of the Arab slave-traders, and of considerable misgovernment while it remained the king's private property. In 1908 the territory was handed over to Belgium, and became the Belgian Congo ; this happened at the end of the European scramble for territory which left the few African-governed countries already mentioned almost as anomalies among British, French, Portuguese, Italian, Spanish, and German colonies and dependencies.

Lugard's Great Work

After the First World War, German colonies disappeared from the map of Africa. Britain remained the leading colonial power (much of the vast French Saharan territories being almost uninhabitable desert). The position there was that British possessions were divisible in four groups West Africa, i.e. Nigeria and the west coast colonies, administered mainly by "indirect rule" ; East Africa, where policy relating to the natives differed between state and state ; the Rhodesias ; and South Africa, a self-governing dominion with a policy based on denial of the equality of races.

The dislocating shock of the intrusion of modern Europe into tribal Central Africa was softened, so far as Nigeria was concerned, by the action of one of the greatest British colonial administrators, Lugard, who at the end of the 19th century explored the country, fought Arab slavers, and brought under control the Muslim emirs in their castellated palaces of red mud. His indirect rule (involving a handful of British officials who supervised African tribal institutions and gradually cut away from them the old cruelties and corruption) was probably too political, ignoring the economic forces which two world wars and the tempest of new scientific and sociological ideas combined to let loose, upsetting the time factor necessary for full development of national, as additional to tribal, consciousness.

Nevertheless Lugard's great work established good faith and confidence where there had been little but exploitation and bitterness, and on that side of Africa racial problems have not been much complicated by multi-racial populations. A native intelligentsia grew up, educated by or among Europeans. The university college of Ibadan has a special link with the University of London. Native local government has taken shape increasingly like the shape of their English model In 1954 the three regions of the colony were united as the Federation of Nigeria, with a governor-general and an elected house of representatives.

Complicated Labour Conditions

At the other end of the scale of relations between the black and white peoples is the Union of South Africa Settlement of the far south began in the early 17th century, when Table Bay was found a convenient harbour on the route to and from India The Portuguese made no settlement, but the English and Dutch, and at one time the French, occupied "the Cape" in turn until 1806, when Britain established her rule over the colony. Then only half the size it later attained, this colony held a few thousand each of Europeans, African and Malay slaves, and Hottentots, with a few Bantu on the eastward side. The British officials called the colonists "the Dutch" ; actually they were a mixture of Dutch, Flemings, and West Germans, with a leaven of Huguenots. The slave-owning mentality was strong from the beginning, and the various peoples, including the small Bushmen on the edges of the settled areas, inevitably produced a very mixed breed, half of whom were free and the other half slaves the "Cape Colonial folk" who from the outset complicated labour conditions in "white" South Africa.

The Boer (i.e. mostly Dutch) farmers who formed the inland fringe of whites regarded themselves as Christian men destined to possess the land and rule the heathen with the sort of heavenly sanction accorded to the Children of Israel in the Old Testament. Not always amenable to control by the Dutch Cape Company itself, they resented and sometimes resisted increasing British

KAFFIR WARRIORS ON THE MARCH. As soon as the white colonists began to penetrate beyond the coastal fringe in South Africa they came into conflict with the Kaffir tribes, and between 1809 and 1877 there were numerous wars.
From Samuel Daniell, "African Scenery," 1804

"interference" with their way of life, especially their treatment of the coloured people both before and after the abolition of slavery.

With the warlike Bantu people ahead, and British officialdom and missionary activity on their seaward side, many of the discontented Boer farmers finally undertook the Great Trek which began in 1835, fighting both Zulus and Matabele and founding new Boer states across the Orange River and the Vaal.

The Cape Colony was granted its own parliament in 1854. The very uneven advance of British expansionist policy (which in 1868 brought under the British crown the district of Basutoland, still part of the largest area set apart for the Bantu to develop along their own lines (according to the segregations policy of the present Union of South Africa) resulted in annexation of the Transvaal in 1877, the short Zulu war of 1879, the grant of independence to the Transvaal in 1881, and the increasing political tangles (involving development concessions, plans for railways, and the importance of Delagoa Bay, the harbour in Portuguese East Africa), which came to a head with the opening in 1886 of the gold-mining area of the Witwatersrand round Johannesburg.

The South African War

A measure of self-government was granted to the Cape Colony in 1872. Cecil Rhodes, dreaming of a Cape-to-Cairo railway through territories to be united in a big British customs union, founded the British South Africa Company in 1889, took steps to secure the province now named Rhodesia, and became premier of the Cape Colony in 1890. Paul Kruger, president of the Transvaal Republic, found his country both enriched and politically embarrassed by the cosmopolitan crowd of "Uitlanders," or foreigners, flocking to the goldfields; denied the franchise, they were expected to rise in arms, and the ill-advised and disastrous Jameson Raid (1895) represented an attempt by Rhodes to harness the Uitlander movement to his own schemes.

Great Britain asserted that her suzerainty over the Transvaal had never been cancelled, and claimed the right to compel reform (e.g. of the franchise) in the republic; the result was the South African war of 1899-1902. When the defeated Boers were granted self government by the British Liberal administration of 1906, the Boer generals Botha and Smuts led their Afrikaner followers to co-operate with their late enemies. In 1910 the Union of South Africa came into being. From 1914 to 1919 the Union, at cost of a serious rebellion in the two ex-republics, supported the British Empire in the First World War. In 1934 the Union parliament became a "sovereign legislative body" without whose specific act no future British legislation could be extended to South Africa. In the Second World War the Union took part against Germany and Italy, although a powerful party would have preferred neutrality.

Against the background of these events the social life of South Africa became shaped into a spectacle of unyielding domination of white people over the coloured. In many respects Africans are subject to a separate administrative organization under the department of native affairs. Special courts administer native law. Certain areas are reserves in which no non-African can hold land. Many laws of the Union discriminate between different groups of the population

Living Standards

In the Union the standards of life of the African community as a whole are relatively higher than those of its neighbours, but in the "shanty" suburbs of Johannesburg uprooted and detribalised labourers live in conditions of squalor probably exceeding that of the worst of the English towns in the industrial revolution. African standards depend entirely on the part played by Africans in the industrial, economic, and domestic life of Europeans. The African needs the European, as the European needs him, and both generally know that extreme believers in segregation cannot hope to drive all Africans into separate native states or reservations; these areas already contain as many inhabitants as they can support.

In industrial life the Africans are every year increasing their recruitment to the ranks of semi-skilled labourers; but many occupations are closed to them, partly at least because they are supposed to be (as a rule) incapable of acquiring certain skills and habits of mind and standards of behaviour.

Multi-racial Societies

The white minority is afraid of three main possibilities: first, that of losing its identity by intermarriage; second, that of African or coloured competition for work, land, and markets; last, that of an electoral system which would give the non-Europeans a political majority. White control of government is therefore regarded as vital. Other races are excluded from political and economic opportunity, and will probably continue to be so excluded until the growing power of African trade unions can be brought to bear against the colour bar and the movement towards *apartheid* or segregation.

In the multi-racial societies of the Central African Federation, and in Kenya, some of the whites have been governing themselves and the other races for years; the white Southern Rhodesians had in fact brought peace to a country

long ravaged by inter-tribal wars, saving the Mashonas from yearly attack by the Matabele. White Rhodesians and Kenyans have tried to perpetuate white supremacy, often by means similar to those used in the southern Union. In the Northern Rhodesian copper belt the African, excluded from skilled or semi-skilled work, detribalised but unready for orderly urban life, has sometimes turned to strikes and riots, while in Kenya the Mau Mau warfare arose partly from exclusion of non-white races from the White Highlands.

North of the Zambezi there is no statutory colour bar, and the African's path of constitutional progress is kept open ; but its advance is conditioned not only by white opposition but also by apathy, misunderstanding, and tribal fanaticism among the coloured peoples, which can only slowly be counteracted.

Given the chance, some Africans are highly educable, can enter fully into Western culture, can organize and command and administer, and can in fact do anything their white colleagues can do. But thousands of years of static cultural life, without stimulus from their environment (of which the humid heat discouraged energetic action), has made many Africans highly resistant to change. Between these two extremes is a vast African population at many different stages of tribal cohesion, of cultural and economic development, of racial consciousness, and of dependence on and resentment against their white administrators, teachers, employers, and exploiters.

LESSON 26

Westernisation of the East

INDUSTRIALISM and its accompanying political upheaval have begun to rock the foundations of life in Asia. Every part of the continent from Sinai to Kamchatka, from the North-East Cape to Ceylon and Singapore, is full of change imposed from above, or fermenting among the teeming millions of whom it has been said that they will never know an end of misery until they learn to stop teeming. Asia covers a third of the land surface of the earth, and holds two-thirds of its population.

Across the immense northern plains nomad tribes wandered, among them the Tartars, who formerly gave their name to the whole territory between the Dnieper and the Yellow Sea. Some of these people are still nomadic, although the settlement and development of Siberia as an industrial region is an outstanding achievement of the 20th century. The name of Tartary survives in the " Tatar " Autonomous Republic (a member of the Russian Socialist Federal Soviet Republic), the area in which the Volga makes its great turn of direction from eastward to southward.

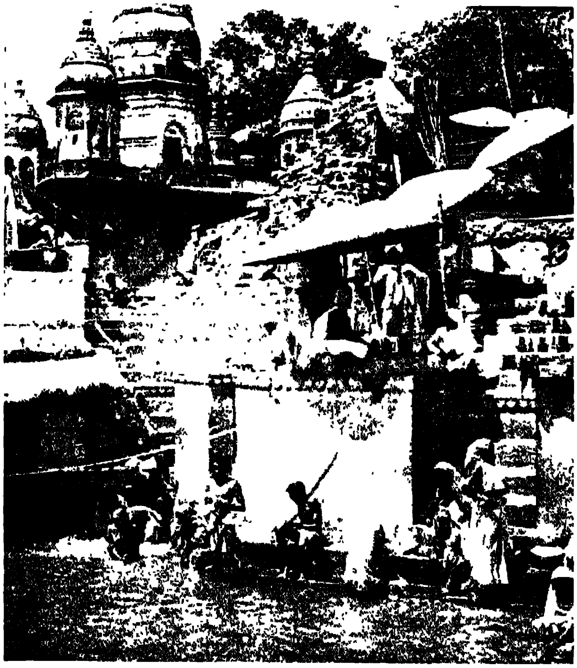
History and social life in Asia more than in any other continent have turned in the past on the clash of nomadic and agricultural peoples. Geographical changes, such as those which covered the Tarim Basin with westward-driven sand-dunes, have also played a part. Separated by mountains, deserts, or jungles, important civilizations grew up and perished, or persisted with little intercommunication until the days of steamship, railway, telegraph, motor vehicle, and aeroplane.

Occasionally a conquerer such as Attila or Tamerlane raged across the continent, his empire collapsing when he died. Jenghiz Khan founded a dynasty which lasted a century, at one time loosely stitching together an area including south Russia, north India, and north China. One of his grandsons, Kublai Khan, the first Mongol emperor of China, failed to receive information he wanted from the pope, and so made Buddhism his state religion. Another, Hulaku, destroyed the dynasty of the Assassins, deposed the caliph of Bagdad, and ruled Persia, Armenia, most of Asia Minor, Syria, and Mesopotamia.

The Great Living Religions

Elaborate urban cultures arose, with literatures and arts and crafts fertilized by such influences as that of Alexander's conquests, or constricted by such religious prohibitions as that laid by Mahomet upon representations of living creatures. All the great living religions originated in Asia. Christianity still exists in the ancient churches of Armenia and Georgia and in the Greek Orthodox form surviving in Russian territories. Islam flourishes from end to end of the continent, especially in the southern half of it. For the first time in 19 centuries the Hebrew religion has a physical home possessed by its believers ; the state of Israel which emerged after the Second World War has drawn to itself descendants of Jews who have kept their faith and national spirit in every part of the world.

Buddhism, next oldest to Judaism, is dominant in Thibet, and shares with other religions the spiritual loyalties of the Himalayan states, Mongolia, Siberia, Manchuria, China, Korea, Japan, Burma, Siam, Indo-China, Ceylon, and parts of the East Indies. Hinduism, the main religion of India, contains a number of elements



INDIA'S HOLIEST RIVER. Hundreds of thousands of people every year bathe in and drink the waters of the Ganges at Benares (as seen in this photo), believing that in this way they will become purified of their sins. Human ashes and corpses are also frequently consigned to the holy stream.

ranging from profound philosophy to simple worship of idols or symbols ; a multiplicity of painted and tattooed marks are worn to differentiate between the various sects. In China, Confucianism (which includes ancestor-worship) and Taoism, both originally philosophic systems rather than religions in a Western sense of the word, flourish together with Buddhism, which also co-exists and to some extent mixes with the Shinto religion of Japan. Beside these are numerous pagan survivals such as the shamanism, or spirit-control, of central and northern Asia, and the animism of primitive communities in India and the south-east.

The Caste System

Each of these religions reflects, and is reflected in, a different social life. Perhaps the most striking interaction of peoples and religion in the world is that apparent in the caste system which still—unofficially—persists in India. There are probably about 3,000 castes, some deriving from tribal or racial elements, some occupational (perhaps originally guilds of craftsmen), others territorial or religious ; conquest, colour bar, and the absorptive power of a static civilization based on a parochial economy, resulted in this very complex and remarkably "co-existent" form of society. Members of each individual caste must eat, drink, or marry only within its own limits ; and no member can move out of the caste into which he is born, although a whole caste may by accumulation of wealth or increase of education succeed in gaining recognition as of higher social standing than formerly. Beyond the main system are the "scheduled" castes—the depressed classes formerly called untouchables. Untouchability was not inherent in the caste system, but incidental to certain indispensable occupations ; beliefs about defilement and the sanctity of cattle were largely responsible for it. Sometimes the scheduled classes may not enter temples, use wells, ride horses, or eat ghee (clarified butter). The sacrifice of cattle, anathema to the Hindu and a pious act to the Muslim, is perhaps an even more serious division between the two great religions of the Indian sub-continent than the theoretical Muslim belief that all men are equal in the sight of God, which itself challenges the whole concept of caste. Muslim conquests were never able to overturn the Hindu structure of society in the sub-continent of India as a whole, although they added to flood and famine and pestilence the deliberate devastation of fertile provinces and the complications of civil war.

Gradually the trading ventures of Europeans led them to possession and expansion of territory. Wars between French and British companies in India affected policy in Paris and London, and eventually the British government took a hand in ruling parts of the sub-continent and establishing political control over nominally independent princes. After the Mutiny of 1857 the government of India was transferred from the East India Company to the Crown. At the time when this happened India was in Macaulay's words "a decomposed society." Professor Lilian Knowles in her *Economic Development of the Overseas Empire*, states that :

> the British took over India in a state of economic nakedness. There were no metalled roads, docks, harbours, canals, hospitals, schools, colleges, printing presses, or other requirements of civilized life, and neither the disposition nor the means on the part of the population to provide them. The canals had dried up and enormous areas of land were sheer waste

British Government in India

Hence the government had to play the part of special providence to millions of almost helpless folk : public works were instituted ; missions, schools, and hospitals were introduced ; civil war was prohibited, and the hand of the oppressor stayed ; new seeds and methods were introduced to the agriculturist ; canals were cut, rivers dammed, reservoirs created ; villages

grew into big towns, centres of manufacturing industry. The cotton goods of Lancashire clothed the sub-continent until the Indians began to manufacture their own dress. A general system of law brought security and justice to men who before had had little acquaintance with either. Something was done to remedy the social evils bound up with Hinduism. Suttee was abolished. Still there remain formidable obstacles to progress, such as illiteracy. But many Indian women are now highly educated, and world tribute was paid to them when in 1953 Mrs. Pandit, leader of the Arab-Asian block in the general assembly of the United Nations, was chosen as the year's president of that assembly.

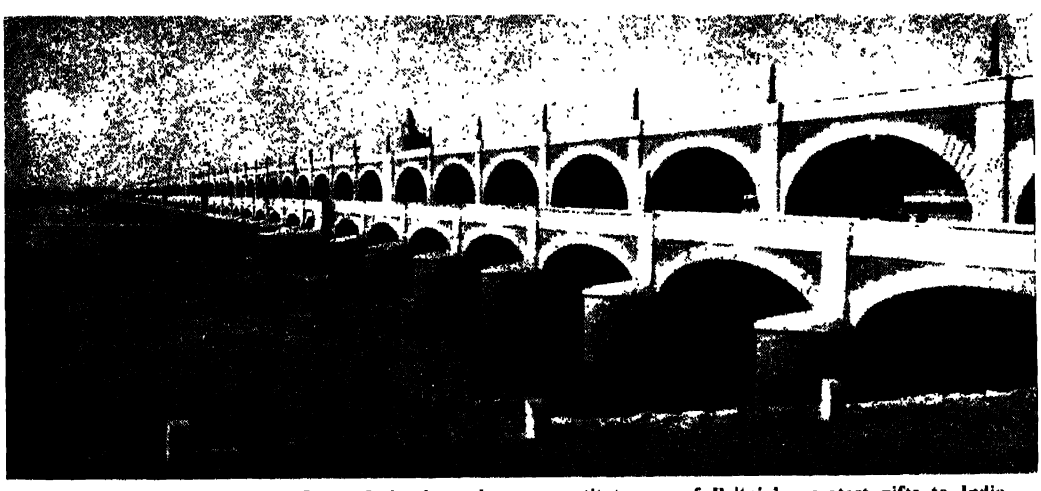
As yet, economic and political improvements have made very little alteration in the lives of the great majority. Human fecundity has defeated the skill of the administrators, the inventiveness of the engineers. Millions of acres have been reclaimed and are now covered with crops, thousands of miles of irrigation canals have brought water to the desert ; the result has been not so much an increase in material well-being, as an enormous addition to the population.

India and Pakistan

In 1947 the structure of British government in India came to an end. The territories administered by it became two separate countries, India and Pakistan, both retaining membership of the Commonwealth of Nations, even after both had reconstructed themselves as republics (in 1950 and 1956 respectively). The formation of the new Muslim state of Pakistan was attended by the two-way flight of refugees, by violence and massacre on both sides, and by frontier disputes still continuing in 1956 between the two countries, notably the problem as to which of them the province of Kashmir should be attached. In 1951 the first Indian general election introduced an enormous electorate—176 million voters—to the use of the ballot paper in 200,000 polling booths. The composite Indian and Pakistani worlds of princes, landlords, industrialists, money-lenders, priests, lawyers, civil servants, teachers, railway officials and operatives, craftsmen, and factory workers on the one hand, and small farmers and tribal village communities on the other, remain massive entities likely to grow in their own ways and to avoid both Western and Muscovite patterns of life.

Trade with China

A century after India had been brought into the sphere of Western influence the British cotton and other manufacturers found a new market in China. But China was not another India. The discreditable opium traffic—which proved so profitable to the British East India Company and so disastrous to the Chinese people, whose government tried to prevent it—led to the "Opium War," which in 1841 resulted in the cession of Hong Kong and the opening of other ports to British trade ; but during subsequent decades the European powers made few territorial gains in China. Western capital slowly worked its way into the country, but the government of the Manchu emperors was strong enough to maintain Chinese territory almost intact. British public opinion gradually



LLOYD BARRAGE, SUKKUR. Irrigation schemes constitute one of Britain's greatest gifts to India. This photograph shows the Sukkur barrage, opened in 1932 by the viceroy, Lord Willingdon, which harnesses the waters of the Indus and makes possible the irrigation of 5,000,000 acres. The total width of waterway is nearly a mile, and the barrage can pass a flood of 1,500,000 cubic feet of water a second.

Courtesy of Messrs. Ransomes & Rapier

reduced the opium traffic, and the Hong Kong opium dens were closed in 1908.

In 1911 the Manchus were deposed. Sun Yat Sen and his fellow republicans, educated for the most part at European or American universities, were nationalist in sentiment and practice. The Chinese republic, launched with high hopes, soon became the prey of scheming politicians and ambitious generals ; for years Chinese history was little but a record of campaigns between rival war-lords, entailing devastation, tyranny, and untold misery among the peasants. When the country had been split into several more or less separate states, the Japanese seized their opportunity and appropriated Manchuria, converting it into the state of Manchukuo.

Turmoil in China

A few years later, in 1937, the Japanese embarked upon occupation and exploitation of the Chinese central territory. Under the leadership of Chiang Kai-Shek, the Chinese fought back. By 1947 the 20th-century nemesis of misrule had fallen upon China. Nothing could appear worse than what was actually happening. Communism offered a change, with some kind of order in it, and endless promises of improvement. The central government steadily lost authority, Chiang Kai-shek being at one time a prisoner of the Communists. The division of power on the Chinese side impeded the war against Japan, and was intensified after the defeat of Japan in 1945. During 1949 the communists gained control of the Chinese mainland, their government under Mao Tse-tung being recognized by most other countries ; the U.S.A. was the outstanding exception. A so-called nationalist delegation (Chiang's supporters) continued to " represent " China in the United Nations organization, although Chiang and his ageing army occupied only the island of Formosa, where they would have been attacked except that the U.S.A. navy was pledged to prevent invasion from the continent.

By 1954 the country was the most populous in the world, 583 million inhabitants out of a world total of 2,652 million. Relations between China and Russia remained obscure ; a guarded cordiality seemed to exist, the brand of communism that suited one giant not necessarily appealing altogether to the other.

China is developing many industries—including textiles, mining, metal-working, extraction of oil and petroleum. Vast waste areas, many of them mountainous, are available for afforestation and cultivation, so that the Asian birth-rate is not so alarming in China as elsewhere. The constitution of the Peoples' Republic of China refers to ownership of the means of production as divided between the state, the co-operatives, individual working people, and capitalists. The skilful Chinese peasant (whose intensive methods have been described as gardening rather than agriculture) remains the essential element in his country's civilization.

Japanese in Aggression

The social historian can be excused considerable pessimism when confronted with the spectacle of Japan, the country whose ruling classes telescoped into a century the process of industrial, economic, and military modernisation which elsewhere occupied some 500 years. When the Japanese " got away with " their Chinese " incident " (it was not at first called a war), the German Nazis and Italian Fascists were immensely encouraged to flout civilized world opinion. The merciless logic of Japanese policy, the fearful atrocities and lying into which it led a tough, superstitious, emotional, and over-disciplined people, brought upon them the first atomic bombs—the logical successors of stone axe, sword, arquebus, and howitzer, but so much more destructive that their use probably induced more sense of guilt in Japan's conquerors than the Japanese felt for all their treachery, during the preceding eight years.

It was the Americans who in 1853 compelled the opening of Japanese ports to trade. In 1871 the feudal organization of the country was abolished From the first days of westernisation and technological advance, the rulers of Japan also set about territorial expansion. In 1894 victory over the Chinese secured possession of Formosa. In 1897 Japan began to import rice to feed her growing population. In 1904 she beat the Russians and took Port Arthur ; in 1910 Korea was annexed. During the First World War, in which Japan was an ally of Britain, France, and the U.S.A., the Japanese secured rights in Manchuria and N. China.

Japan in Defeat

The attack on Manchuria, 1931, led up to the war with China, during which the ancestral spirits of the Japanese governing class counselled them to attack, without declaration of war, the U.S.A. Pacific fleet in Pearl Harbour, Hawaii. Initial successes took Japanese armies to Singapore, Rangoon, Mandalay, Bangkok, Saigon, and some of the East Indian islands. Japan clutched at the hegemony of the whole of eastern Asia, representing her armies as liberating the native peoples from British and Dutch domination, but her own proved no more welcome. Although white prestige in south-east Asia was very badly damaged, the series of unconditional surrenders of Japanese naval and military forces left no illusions as to the overwhelming defeat of Japan. The necessity of not leaving the country helpless before the advance of communism entailed her rearmament with the help of her late enemies.

When the Second World War ended, much of

Asia was in political turmoil which has since continued. From the U.S.S.R. the doctrine of communism seeped southward into the huge areas where industrialism of Western type—which in the Near and Middle East is principally concerned with oil—is rapidly altering social conditions and facilitating the spread of nationalistic aspirations and experiments. Within the decade after the war British rule disappeared from India, Ceylon, and Burma, French rule from Syria and Indo-China, and Dutch rule from the Indonesian Archipelago. The upsurge of Asians into the administration of their own countries is one big social development, necessitating a great educational advance.

Clash of Ideologies

The clash of ideologies in the Korean war of 1950–53 was echoed in what used to be French Indo-China, and is now four independent states, North and South Viet-Nam, Laos, and Cambodia. In Malaya communist guerrilla forces (principally Chinese) tried to represent themselves as an army of liberation. Here protected hostilities continued side-by-side with striking social developments. The first national election of the new Federation of Malaya took place in 1955, and the grant of independence in 1957. This plural society of Malaysians, Chinese, Indians, and Pakistanis is gradually being drawn together. The Chinese have always been the hardest section to assimilate ; a successful feature of government action has been the resettlement of Chinese squatters from the jungle edges to 500 new villages away from the jungle, where many continue their agriculture but many others become craftsmen or workers in the rubber plantations and mines. The neighbouring colony of Singapore was also given a new constitution in 1955 ; whether so small a unit could sustain independence on a federal basis, which its legislative assembly claims, remained to be established.

Refugee Problem

At the opposite end of the continent, where one Western-type country, Israel, is surrounded by the Arab countries whose oil (with that of Persia) gives them enormous importance to Britain and the U.S.A., old feuds and new pressures kept the Asian scene restless. Five Arab states (including Egypt, whose strip of Asiatic soil sticks into the flank of Palestine) attacked Israel, and were beaten in battle. The Arab leaders had told Arabs resident in Israel to flee across the frontiers until the Jews were swept into the sea ; thus at the end of hostilities the Arab countries were left with swarms of wretched refugees, whose plight they were less concerned to relieve than to use as propaganda against Israel. Of Israel's state-building enterprise they are bitterly jealous.

Existence of this refugee problem complicated still further the scene already criss-crossed with oil pipe-lines, with nationalistic fervours, jealousies between Arab states for leadership of the Arab world, and communist fomentation of unrest.

LESSON 27

The Emancipation of Women

At certain times, in certain places, women of rank or character or both—Hatshepsut of Egypt, Theodora of Byzantium, Joan of Arc, Catherine of Russia—have achieved equality with, or supremacy over, leading men of their age. Myth and legend contain traces of matriarchal societies, and a goddess haunts the dawn of many civilizations. Here and there, as in New Guinea, a primitive tribe still displays a reversal of the usual attitude of collective masculine control of and contempt for women (among other tribes who maintain that usual attitude, or keep a gentle or aggressive equality between the sexes).

But, on the whole, man has taken every advantage of his usually superior strength and of his biological good fortune in the matter of child-bearing. When he hunted mammoth and deer across the plains, his woman stayed in the cave-mouth, tending children, scraping hides, preparing food, shaping flints, gathering brushwood for the fires that kept wild animals away. When he became a pastoralist, she nursed calves and lambs. When at last he took to agriculture, she shared his labour in the fields and suckled their child in the intervals of digging, sowing, planting, and reaping.

The classical Roman showed more consideration for women than did his Greek precursor, although both of them accorded great respect to priestesses of religion. Islam condemned women to more than a millennium of almost mindless subjection. Some of the barbarian invaders of Europe listened to " wise women," but the dark ages were never darker than in the relationship of the sexes. At the end of that period a curious literary-cum-musical cult of worship or idealisation of " fair ladies " of social standing arose, particularly in Provence and Languedoc. Increasing devotion to womanhood in the person of the Virgin Mary may have helped its development, but the cult was almost stamped out when the Church launched the northern French against the Albigensian

heresy, with which many of the troubadours may have had some connection.

Some of the words and ideas of the cult survived the Middle Ages, but medieval "chivalry" in its domestic application was usually an ideal rather than a practice. Men-at-arms who respected ladies of rank did not always extend that respect to peasant girls or to merchant wives in sacked cities. Within the family, wives and daughters were much beaten.

The age of discovery dawned. Men found America and the Indies but women found no lightening of their load. With the coming of steam and machinery mothers, wives, and daughters flocked into the factories or were set to work in the darkness of the mines. Some no doubt welcomed the chance to earn even a puny wage, and their homes were not of a kind to encourage them to stay there, but the factories were noisy and ill-ventilated and the hours of labour long. The prosperous classes kept a host of servants, releasing their own womankind for lives of idleness and vacuity ; anything beyond trivial accomplishments were generally frowned upon, except in those of the shopkeeper class whose skill in dressmaking, laundering, and cooking contributed to the comfort of their customers.

Women's Rights

In 1792 the noble-minded Mary Wollstonecraft made her historic plea for the emancipation of upper- and middle-class women from the stultifying custom of the time. She demanded that they should no longer be treated as dolls to be alternately petted and ignored, but should be considered as human beings with minds to be cultivated, bodies to be exercised, natural appetites to be recognized and satisfied. She exposed the hypocrisy of those who demanded liberty yet denied its necessity to half the human race. "The rights of humanity," she said, "have been confined to the male line from Adam downwards." Rousseau deservedly drew her fire, for he who had done so much to arouse the spirit of revolution had also written :

> The education of women should always be relative to men. To please, to be useful to us, to make us love and esteem them, to educate us when young, to take care of us when grown up, to advise, to console us, to render our lives easy and agreeable—these are the duties of women at all times, and what they should be taught in their infancy

When such views were held by an apostle of advanced thinking, it is understandable that the aged upper-class gossip Horace Walpole called Mary Wollstonecraft "a hyena in petticoats."

Half a century later, in mid-Victorian times, the middle-class woman was still taught to regard marriage as the only career open to her ; failing this, she lived on the money left her by her father, or as a brother's dependant, or perhaps made a precarious livelihood as a nursery governess. The peasant girl looked forward to marriage. The town girl could also go into the factory, serve behind a counter, or enter domestic service. Mary Wollstonecraft's attack on prejudice was largely repulsed in the years when any reform was tarred with the brush of revolution, but other brave women took the question up, and were denounced as unwomanly cranks, blue-stockings, and so on.

> Men of England ! (Charlotte Brontë [1816–55] burst out in *Shirley*) look at your poor girls, many of them fading around you, dropping off in consumption or decline ; or, what is worse, degenerating to sour old maids—envious, back-biting, wretched, because life is a desert to them ; or, what is worst of all, reduced to strive, by scarce modest coquetry and debasing artifice, to gain that position and consideration by marriage which to celibacy is denied. Fathers ! cannot you alter these things ?

Mill's Classic Plea

Other distinguished writers, including Eliza beth Barrett Browning, George Eliot, Mrs. Gaskell, and Harriet Martineau, upheld the cause of their sex. Florence Nightingale by her devotion at Scutari and in the Crimea opened a new career to women. Josephine Butler (1828–1906), fought for 20 years against the Contagious Diseases Acts of 1866 and 1869, which introduced the Continental system of legalised vice in garrison towns ; she braved social ostracism and all the power of officialdom on behalf of a most unhappy class of women. John Stuart Mill (1806–73) urged that

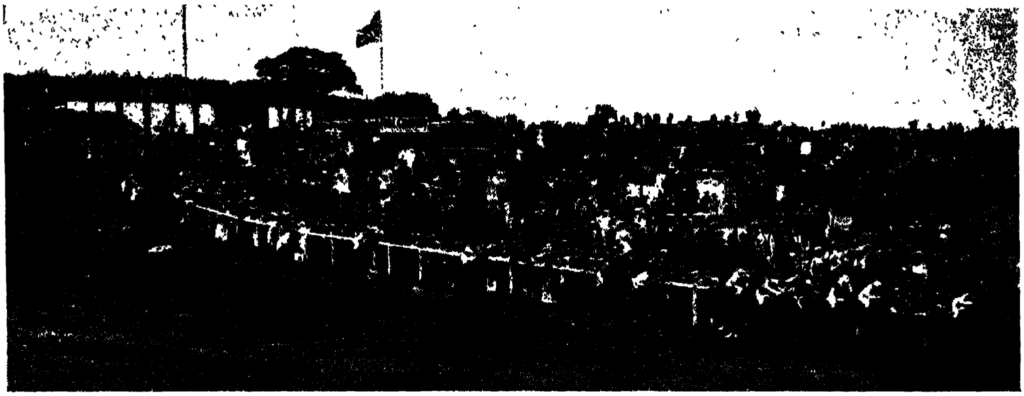
> the legal subordination of one sex to the other is wrong in itself and now one of the chief hindrances to human improvement that it ought to be replaced by a principle of perfect equality, admitting no power or privilege on the one side, nor disability on the other.

Mill's classic plea appeared in 1869. Thirteen years later, women married after 1882 were given control of the property they possessed before marriage or which subsequently came to them. In 1884 it was enacted that a wife should no longer be liable to imprisonment for refusing to obey an order made by a court for restitution of conjugal rights. Thus the law recognized the rights of married women.

Women in the Professions

Higher education for women was already well under way ; in London, Queen's College was opened in 1848 and Bedford College in 1849 ; the Cambridge Colleges, Girton and Newnham, date from 1869 and 1875 respectively ; Lady Margaret Hall, Somerville, St. Hugh's and St. Hilda's were established at Oxford between 1879 and 1893.

Women began to enter the professions. The first woman to be placed on the British medical register was Dr. Elizabeth Blackwell (1821 1910), a native of Bristol, who obtained a medical diploma—the first granted to a woman —in the U.S.A. ; the second was Elizabeth Garrett (Dr. Elizabeth Garrett Anderson, 1836-



MARTYR FOR "THE CAUSE." In the course of the Derby of 1913 a "suffragette," Emily Davidson, rushed out from the crowd as the horses rounded Tattenham Corner and flung herself in the way of Anmer, the King's horse. Severely injured, Miss Davidson died shortly afterwards. Her funeral was the occasion of an impressive demonstration by supporters of the woman suffrage movement.

1917), who played a notable part not only in providing medical education for women, but in the women's movement generally. The first woman solicitor and the first woman barrister in England were admitted in 1922. No women have ever been admitted to the orders of the Anglican and Roman Churches, but the Society of Friends (Quakers) have always kept a complete equality between men and women and the Salvation Army has relied largely on women officers. The Free Churches did not institute women ministers until the 20th century.

Woman suffrage was first advocated in parliament by John Stuart Mill in 1867, and during the next 50 years seven bills providing for the granting of votes to women passed their second reading in the Commons and failed to go further. After the Liberal triumph in 1905 the woman suffrage movement grew apace, and the militant tactics of the Women's Social and Political Union, founded in 1903 by Mrs. Emmeline Pankhurst (1858 1928), added a new zest to politics.

Suffragette Tactics

Led by Mrs. Pankhurst, her daughters Christabel and Sylvia, "General" Mrs. Drummond, Miss Annie Kenney, and Mrs. Pethick-Lawrence, the "suffragettes" pestered cabinet ministers, chained themselves to the grille in the house of commons, fired letter-boxes and even houses, and generally made themselves as obnoxious as possible. Scores were arrested, and a special Act of Parliament—the "Cat and Mouse Act"—was passed to meet the case of those women who went on hunger-strike as soon as they were imprisoned. One suffragette even flung herself to death beneath the horses running in the Epsom Derby race in 1913. Not until 1918, when the women of the country had proved their worth in munition factories and in other war-time activities, did parliament grant the franchise to women of 30 and over. Ten years later women were put on an equality with men so far as voting was concerned.

To-day women are doctors and lawyers, teachers and preachers, journalists and members of parliament, stenographers and business chiefs, civil servants and technologists, research-workers and members of the Services. During the Second World War, as during the First, they showed that there were few jobs which could be held to be the natural, as opposed to the conventional, preserve of the male sex.

Equal Pay for Equal Work

In the one supremely important task which only women can do, there has also been progress. Motherhood is still a dangerous occupation, but maternity homes, hospitals and "twilight sleep" lessen its risks and pains. The tyranny of unwanted pregnancies has been diminished by contraception since the publication in 1877 by Charles Bradlaugh and Annie Besant of Charles Knowlton's birth-control pamphlet, *The Fruits of Philosophy*. In recent years knowledge of contraceptive methods has been popularised by the books of Dr. Marie Stopes.

The process of emancipation of British women begun in the reign of Queen Victoria has now, in the reign of her great-great-grand-daughter Queen Elizabeth II, reached a point where the problem of "equal pay for equal work" is in process of solution. In the advance of the position of women in other parts of the world, British women have frequently played a noble part as missionaries, doctors, and teachers. Full partnership between men and women in the interests of the community is a logical development in the British way of life.

LESSON 28

Man's Achievements in the 20th Century

FROM the dawn of creation, space and time have challenged all living things. In fits and starts, some measure of success has attended man's efforts to live at increasing pace—to shorten the miles, as it were, and to pack more and greater achievement into the 60 minutes of every hour. Conquest of the roads, of the seas, and of the air has increased his restlessness.

With each attainment, new and sometimes startling vistas have been opened and a new goal set. Standards and methods of living have changed immeasurably, but still a vast tangle of difficulties has remained. The roads and the seas and the air have become overcrowded and man's attention turned to outer space. And the tempo of his striving increases.

The First Motor Car

The 20th century was still 11 years distant when the first motor car, inaugurating a new era in travel, ran in Great Britain. That was in 1889. To-day there are well over 3,000,000 cars on Britain's roads. Until 1896 every self-propelled road vehicle had to be preceded by a man carrying a red flag, and speed was restricted to 4 m.p.h. Certain road restrictions are still enforced, but in motor racing contests speeds in excess of 100 m.p.h. are attained. The British racing motorist Sir Malcolm Campbell (1885–1948) was the first man to drive at 300 m.p.h., in 1935—the fastest man on earth. His car, *Blue Bird*, was powered by two Rolls-Royce aeroplane engines totalling 2,500 h.p.

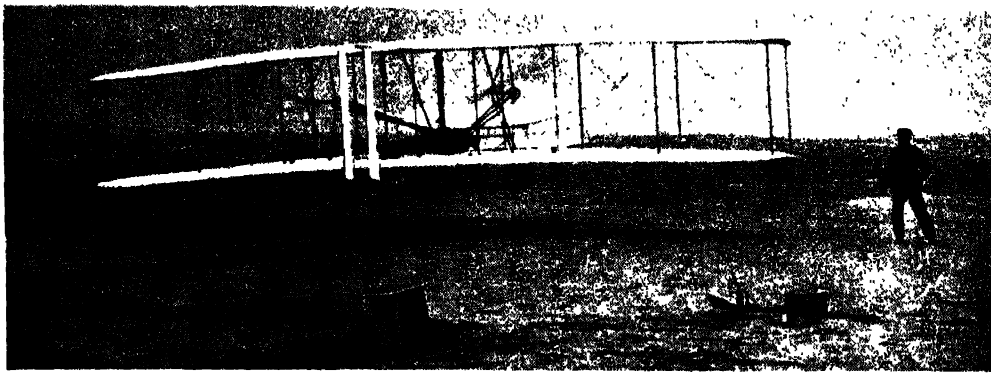
All this stems from the 4-h.p. four-wheeled car built in 1887 by Gottlieb Daimler (1834–1900), which is generally regarded as the fore-runner of the motor car of to-day. Mass production methods brought motor cars within the reach of vast numbers of people. The pioneer in this field was an American, Henry Ford (1863–1947). He founded the Ford Motor Company in 1903, at Dearborn, Michigan, and this developed into the world's largest motor-manufacturing concern. During a period of 20 years from 1908 some 15,000,000 of his "popular" model were manufactured. Later his works were established in several countries, including England (at Dagenham, in Essex). Other mass-production pioneers included, in England, William Morris (b. 1877), who became Lord Nuffield in 1938 and whose first cars were manufactured in 1912, at Cowley, near Oxford; and Herbert Austin (1866–1941), who became Lord Austin in 1936, founder of the Austin Motor Company in 1905 at Longbridge, near Birmingham. The factories gave rise to new centres of population, with employment at high wages, and mechanised high-speed travel became the order of the day.

Coming of Controlled Flight

The highest speeds so far possible on the ground appear trivial in comparison with speeds now commonplace in the air. The plane has outstripped the car, although the first man to fly in a heavier-than-air, power-driven machine did not rise off the ground until the year in which Ford started his mass production of motor cars—1903. It was on Dec. 17 of that year, at a site near Kitty Hawk, in N. Carolina, U.S.A., that this stupendous achievement of controlled flight took place. The Wright brothers, two sons of a clergyman, who constructed and flew the plane, had carried out their experiments in the spare time left to them from the running of a bicycle repair shop in Dayton, Ohio. They had the benefit of the failures of many other experimenters, but some of their work was on original lines.

ONE OF THE FIRST. Ten years after the petrol motor had been introduced, the first motor cars were seen in London streets. This is a 4½ h.p. Daimler built in 1895, with tiller steering.

They had been successful with numerous gliding flights at Kitty Hawk, and into a biplane glider, 40 feet 4½ inches between wing-tips, they fitted a 8–10-h.p. petrol engine to drive two propellers. The glider was without wheels, and the take-off was effected from a trolley which ran on a 60-foot monorail. The first flight was for a distance of about 120 feet and



FIRST CONTROLLED AEROPLANE FLIGHT. On December 17, 1903, the aeroplane built by two American brothers, Orville and Wilbur Wright, was flown for a matter of seconds. This was the first flight in a power-driven heavier-than-air machine. In 1928 the machine was presented to the Science Museum, South Kensington, London, by Orville Wright, but it was returned to the U.S.A. in 1948, to be exhibited in the Smithsonian Institute, Washington.

it lasted 12 seconds. The pilot was Orville Wright (1871–1948). Later the same day Wilbur Wright (1867–1912) flew 852 feet, in 59 seconds. The flight ended in a crash, and the machine was wrecked. But the brothers had learned a tremendous lot in that one day, and they set to work to effect various improvements.

Flying did not "take on" all at once. Popular interest was not really aroused until the English Channel was flown, on July 25, 1909. Louis Blériot, piloting a monoplane, did the 20 miles crossing (Calais-Dover) in about 30 minutes. Twenty-five years after the Wrights' first flight, Bert Hinkler made the first solo flight from England to Australia (1928). In 1951 a jet bomber crossed the Atlantic (Northern Ireland to Newfoundland) in 4 hours 19 minutes. In 1956, Peter Twiss established a world speed record of 1,132 m.p.h.

And so it has gone on -flying faster than sound. The aeroplane has opened up regions of the world hitherto inaccessible, and—as with the manufacture of motor cars– large centres of population have been built up around the expanding works. In the construction of aircraft there is big money, with correspondingly high wages alike for skilled mechanics and for workers not so skilled.

CUTTING THROUGH THE ISTHMUS OF PANAMA. The Culebra Cut the deepest excavation made in the Panama Canal construction, as it appeared in 1913 before the water was admitted to this section. Time taken by a vessel to complete the passage of the canal is from 6 to 8 hours, about half that time being accounted for by a necessary slow-down at each of the several locks.

Aircraft soon presented a challenge to the sea and to the railways, and the ships and the trains lost many passengers and much goods traffic to the swift air routes. Nevertheless, there were notable achievements on and in connexion with the sea.

In 1862 the fastest Atlantic passage was achieved by the *Scotia* (over 3,000 tons); she did it in 9 days. That time was reduced by the liner *Queen Mary* (over 81,000 tons) in 1938 to 3 days 20 hours 42 minutes, and by the *United States* (over 51,000 tons) in 1952 to 3 days 12 hours 12 minutes. A tragic forerunner of these giant craft was the *Titanic*—an unsinkable ship, as the world believed. She was also the world's largest ship—and she did not survive her maiden voyage. On the night of April 14, 1912, while on her way from Southampton to New York, the *Titanic* collided with an iceberg, and sank in a calm sea. The death-roll was 1,502 out of a total of 2,207. Valuable lessons were learned from this gigantic disaster—and the shipyards turned out still larger, and swifter, vessels.

The Panama Canal

A mighty undertaking was the construction of the Panama Canal, an artificial waterway gouged through the isthmus of Panama—the isthmus that connects North and South America. The project had been in men's minds for centuries, but such was the nature of the task that not until 1914 did it become a reality. In that year the canal was opened to all the world's shipping—a total length of about 50 miles of waterway connecting the Atlantic and the Pacific oceans. Passage of the Panama canal by big (and little) ships saves tremendous distances, reducing the passage from Liverpool to San Francisco by 5,666 miles, Liverpool to Vancouver by 6,000 miles, New York to San Francisco by 7,878 miles, New York to Yokohama by 3,768 miles.

Entertainment linked with utility in the form of radio burst upon the world in the first quarter of the 20th century; in Great Britain, the first B.B.C. programme was broadcast on November 14, 1922. Then came television; a demonstration was given by J. L. Baird (1888-1946) in England in 1926, and his particular process was used for public transmission until 1936, when another was adopted.

Medicine, and the Atomic Age

In medicine and surgery notable 20th century achievements centre around such words as insulin, penicillin, and sulphonomides. The discovery of insulin in 1922, by Sir Frederick Grant Banting (1891–1942) in co-operation with J. R. Macleod and C. H. Best, revolutionised the treatment of diabetes. In 1928 Sir Alexander Fleming (1881–1955) discovered the antibiotic penicillin, which prevents the growth of various disease bacteria. It is used in treating pneumonia, blood poisoning, and open wounds. The introduction of the sulphomonides by Gerhard Domagk (born 1895) in Germany in 1935 paved the way for the development of a whole series of drugs for the treatment of various diseases caused by microbes; the drugs interfere with the nutrition of the bacteria and prevent them from multiplying.

As the art of healing progressed, so did man's powers of destruction increase enormously The vast social and political upheavals consequent upon two world wars were carried forward into the so-called Atomic Age. A large question mark is presented by the increasing development of atomic energy. Some visualise the possible disintegration of civilization; others see on the horizon a well-ordered revolution for the better in the lives of all mankind.

BOOK LIST

General. *Universal History of the World*, ed. by Sir J. A. Hammerton (Amalgamated Press); *Outline of History*, H. G. Wells (Cassell); *Martyrdom of Man*, Winwood Reade (Watts); *History of England*, G. M. Trevelyan (Longmans); *Mutual Aid*, P. Kropotkin (Penguin).

Ancient. *Ancient Hunters*, W. J. Sollas (Macmillan); *Everyday Life in the Stone Age*, M. & C. A. B Quennel, also *Life in Greek and Later Times* (Batsford) *Our Prehistoric Ancestors*, D. Dawson (Methuen) *Ancient Times*, A. W. Breasted (Ginn); *Greek Commonwealth*, A. Zimmern (Cl. P.); *Roman Society from Nero to Marcus Aurelius*, S. Dill (Macmillan).

Middle Ages. *Medieval People*, Eileen Power (Methuen): *English Life in the Middle Ages*, L. F. Salzman (O.U.P.); *Life in the Middle Ages*, G. G. Coulton (C.U.P.) and *The Medieval Village* (C.U.P.).

Modern. *History of Civilization in England*, H. T. Buckle (O.U.P.); *Rise of Rationalism in Europe*, W. E. H. Lecky (Longmans); *America: The Story of a Free People*, A. Nevins and H. S. Commager (O.U.P.); *Soviet Communism: A New Civilization*, S. & B. Webb (Longmans); *Russia*, Sir B. Pares (Penguin); *The Chinese*, W. Galbraith (Penguin); *History of Modern China*, Latourette, K.S.A. (Penguin).

Economic. *Economic Organization of England* and *English Economic History*, W. J. Ashley (Longmans); *Growth of English Industry and Commerce*, W. Cunningham (C.U.P.); *Economic History of England*, Charlotte M. Waters (O.U.P.); *The Common People: 1746 to 1938*, G. D. H. Cole and R. Postgate (Methuen). *Industrial and Commercial Revolutions in Great Britain in the 19th Century*, L. C. A. Knowles (Routledge); *History of Trade Unionism to 1920*, S. & B. Webb (Longmans); *The Town Labourer, 1760–1832, The Skilled Labourer, The Age of the Chartists, The Rise of Modern Industry*, J. L. & B. Hammond (Longmans); *Poverty and Progress*, B. Seebohm Rowntree (Longmans); *The English Middle Classes* and *Professional People*, R. Lewis and A. Maude (Phoenix House); *Studies in Class Structure*, G. D. H. Cole (Routledge and Kegan Paul).

SPANISH

As well as being a magnificent language, with a vast and delightful literature, Spanish is important in that it is spoken all over Central and South America. The student can be encouraged by the fact that Spanish grammar is easy and straightforward, and a good practical working knowledge of the language can be achieved in a short time. This Course represents a first approximation to a basic Spanish.

Other Courses on modern languages are in Vol. 2 (FRENCH), *Vol. 3* (GERMAN), *Vol. 5* (PORTUGUESE *and* RUSSIAN), *and* ITALIAN *in this volume.* PHILOLOGY, *which is complementary to the study of all languages, is dealt with in Vol. 5.*

11 LESSONS

LESSON 1

Alphabet, Pronunciation, Articles

THE Spanish Course consists of 11 Lessons. Some are longer than others ; some contain matter that is given only for reference ; Lessons 9 and 10 consist of vocabulary. Hence the length of a Lesson or the matter it contains is not intended as a guide to the time which the student must devote to it. Roughly, the student should be able to master one column of this Course per day and, if he can maintain that standard of progress, his advance in knowledge will be very good. At the rate of one column per day, the Course should be completed in 17 weeks.

An Easy Language

Spanish is one of the easiest and most pleasing of languages. The grammar is straightforward; there are no long lists of exceptions. A good practical working knowledge of Spanish can be achieved in a shorter time than of any other European language. It is, indeed, *after* that knowledge has been achieved, and the student begins to read literature, that he begins to discover that the real difficulty of the language for the foreigner lies in the richness of its vocabulary.

Even when every line of this Course is known, the most conscientious and industrious student will find, in reading a book which seems easy enough, that he will come up against words not to be found in any dictionary, but made by the author by adding one or more of the augmentatives or diminutives given in Lesson 8 under the heading of " Word Building."

Test of Word Building

It is then that his knowledge of the language and the resources of his intelligence will be put to the test. This is the *real* difficulty of Spanish. It is precisely for this reason that the system of word building is stated in considerable detail in Lesson 8, where much more is to be found about it than in the average grammar. While in this Course the grammar is reduced to a minimum, and a list of absolutely essential words is given—words which must be known —we have thought it desirable to give a generous statement of the principles of word building because, after the Course has been completed, this serves as a key to hundreds, possibly thousands, of words that might cause the student some difficulty.

Yet such is the nature of Spanish that the experience of most beginners is to find in it a fascination and a pleasure which soon prove to be a very great help to study. Advance becomes rapid, for the mechanics of the language are reasonable and very logical. There is one claim that can be made for Spanish with absolute assurance : *it can be learnt without the aid of a teacher.* Even the pronunciation can be learnt from a book, though help from a native with pronunciation in the first few pages will never be regretted.

Throughout the Course, concentrate on learning as many words as possible. From the very beginning keep a notebook—and add to it daily not fewer than ten new words.

Alphabet and Accents

The alphabet is the same as in English, but the Spanish Academy treats **CH, LL,** and **Ñ** as additional letters ; **W** is to be found only in words of foreign origin.

There is one " graphic accent " (´) and it is used for two purposes : to indicate the syllable of a word that is to take the principal stress ; and to mark a distinction between words that would otherwise be written exactly alike. Thus in the word **difícil**, the í is stressed or accentuated ; and **él** means *he*, while **el** without the graphic accent means *the*.

The diaeresis (¨) is used over **u** in **güe** and **güi** to indicate that each vowel is to be pronounced : **vergüenza**, *shame*. The tilde (˜) is used only over the letter N, to indicate that it is to be pronounced like English *ni* in such words as onion, companion : **Señor**, *Mr., Sir*.

Each letter in the Spanish alphabet has one invariable sound, excepting C and G, which have two (as will be explained later).

Accentuation or Stress

All words ending in a vowel, N, or S, are accentuated or stressed on the *last syllable but one*. All words ending otherwise are stressed on the *last syllable*, unless there is a graphic accent (´) and then *the vowel so accented* is given the stress. Thus :

dinero, *money* ; **volumen**, *volume* ; **antes**, *before* (**dinER'o, volU'men, AN'tes**). **La seguridad**, *security* , **esperar**, *to expect, hope* (**seguriDAD', esperAR'**). **El Perú**, *Peru*. **Cádiz**. **El cónsul**, *the consul*. **El país**, *the country*.

In these simple rules the student of Spanish has the complete solution of what is, in such languages as English and Russian, the problem of stress—one that is often of great difficulty.

Vowels. Vowel sounds are of very great importance in Spanish. As there are no double consonants (except **ll, rr,** which, for pronunciation, represent single sounds) there are no very short vowels in the English or German sense, but only stressed or unstressed vowels. Every

Spanish vowel sound is pure, clear, and well rounded—especially when it is stressed.

A is pronounced like **a** in *father*.
E „ „ **a** in *ace*.
I „ „ **i** in *machine*.
O „ „ **o** in *note*.
U „ „ **u** in *rule*.
Y as a vowel is the same as **I**. As a consonant it is like English **Y**.

Diphthongs and Triphthongs

The two vowels **I** and **U** are used with other vowels to form diphthongs and triphthongs. Then the vowel emphasised is the one *other than* the **I** or **U** :

Santia´go, pie´dra, trei´nta, fue´go, puer´ta, cua´nto.

In all vowel compounds not made with **I** and **U**, each vowel must be pronounced with equal clarity : **real, aéreo** (four syllables). Pronounce Spanish **AI, AY** like *ah-ee* (spoken quickly), **(hay)**.

oi, oy, almost like	*oy* in boy	**(hoy)**
ei, ey, „ „	*ay-ee*	**(ley)**
au, „ „	*ah-oo, ow*	**(pausa)**
ua, „ „	*wah*	**(cuanto)**
ue, „ „	*wey*	**(fuego)**
uo, „ „	*oo-oh*	**(continuo)**
ui, uy, „ „	*oo-ee, wee*	**(muy)**
uai, uay „ „	*wah-ee*	**(Uruguay)**
uei, uey „ „	*woo-ay-ee*	**(buey)**
ia, „ „	*ee-ah*	**(seria)**
io, „ „	*ee-oh*	**(acción)**
ie, „ „	*ee-ay*	**(piedra)**
iu, „ „	*ee-oo*	**(viudo)**

All other vowel compounds like the above follow the sounds of the simple vowels, in accordance with the rules given.

Consonants

Unless mentioned below, consonants are pronounced as in English. Note well the following :

B and **V** are pronounced almost alike in the greater part of Spain (a less explosive sound than either letter in English, with the lips not quite closed). The beginner is advised to keep to the simple English **B** and **V** sounds, until he can get a Spaniard to pronounce them for him.

C (1) before **e** and **i**, like English *th* in thin (**cinco**, *five*) ; (2) otherwise it is like English *k* (**cura**, *parish priest*).
CC is always followed by **i**. Then the first **c** is like *k*, the second like *th* (**acción**, pr. "*akthiohn´*").
CU like *qu* in quick, (**cuento**, *a story*).
Ch like *ch* in child (**muchacho**, *boy*).
D, a less distinct sound than English *d*, with a flavour of the *th* in *though* between vowels and at the end of a word : **ciudad**, *city* (pr. *theeoodhadh*). Before *r* it is like the thick Irish sound heard in the Connaught pronunciation of words like *drink* etc.

NOTE. At the end of a word **D** is often silent, for example, in the word **usted** (*you*) which is generally pronounced *oosthay'*. This is common to the whole of Spanish America. In some parts of Spain it is regarded as a slight affectation to pronounce **usted** otherwise than as indicated. The Castilian pronunciation is *oosthayth'*.

G (1) before **e** and **i**, like Scotch *ch* in loch or German *ch* in Bach ; (2) otherwise like hard *g* in go (**siglo**, *century*). **General**, *general*, pr. *henneral*, with a strong **H** sound.
GU (1) before **e** and **i**, like *g* in go (**guerra**, *war*) ; (2) before **a** and **o**, like *gw* (**guante**, *glove*).
GÜ, the **u** is given a diaeresis to indicate that it is to be pronounced before **e** and **i** (**vergüenza**, *shame*—pr "*vergooen'tha*").
H, always silent.
J, like Scotch *ch* in loch, or German *ch* in Bach.
JU, before a vowel like a strongly aspirated English *wh* (**Jueves**, *Thursday*—pr "*Whay'vess*")
LL, like English *lli* in million.
NG, like English *ng* in sing (**Domingo**, *Sunday*)
Ñ, like English *ni* in onion (**Señor**, *Mr.*, *Sir* pr. "*Saynyohr*").
QU is always followed by **e** or **i** and sounds like **k** (**queso**, *cheese*).
R is sounded more than in English and is strongly rolled at the beginning of a word and after **l**, **n**, **s** (**alrededor**, *around*)
RR, a very strong **r** sound, with a fine roll about it (**perro**, *dog*, **cerrar**, *to shut*, *lock*).
S, always hissed as in *sink*, *so*. (Never as in English *rose*)
T, more distinct than in English.
X, as in English. In old Spanish it was pronounced like the modern Spanish **J** (Don Quixote, now written *Quijote*).
Z, like English *th* in think (**zapato**, *shoe*).

Spanish-American Usage

The pronunciation given above is Castilian, which, in Spanish America, is often regarded as Oxford (or British Broadcasting Corporation "standard") English is regarded in the U.S.A. That is to say, it is considered to be affected. Spanish America follows Andalusian pronunciation, which is softer and less definite than Castilian. Let not the student forget that there can be only local arguments against following Castilian. Every Spanish-American country has its peculiarities of pronunciation ; even in Spain there are many differences. It is, therefore, advisable for the beginner to keep to the rules given for standard Spanish.

There are, however, a few points worthy of notice in regard to Spanish-American pronunciation : they may help the novice to avoid feeling over-conscious of his Spanish-Spanish when speaking to Spanish-Americans.

B except before **r** or **l** is generally pronounced **v**.
C before **e** and **i** is everywhere in Spanish America pronounced like English *SS*. (Thus, **cinco** is pronounced "*sinco*" instead of "*thinco*," as in Spain.)
Z is always like English *SS*. **Vez** (*time*)—pr. "vayss."
LL is pronounced like an English *YY* : **Caballero**, "*cavay yero*" (*gentleman*). This applies to all Spanish-American countries, except in the River Plate countries, where **LL** is almost like

an English *J*: **Pollo** (*chicken*) is there pronounced like English "*pojo*."

Consonantal Y in the River Plate area is also like an English *J*: **Yo** (I)—pr. "*Jo*."

S: in Chile this is slurred, almost dropped entirely (**Usted**—pr. "*oo'thay*"—here the apostrophe represents a slight stop, or hesitation, where the **S** is dropped).

In such endings as **-ado** the **d** is often silent: **colorado** (*red*) pr. "*colorao*."

Many other differences from Castilian pronunciation exist throughout Spanish America, but the above are of most importance. There are also a few slight differences in orthography: **j** is often used instead of **g** before **e** and **i**—**jeneral** for **general**: **i** is often used for **y**—**hai** for **hay** (*there is, there are*), and so on.

But apart from pronunciation and such very slight differences in orthography, Spanish is everywhere the same, and there is far less difference between the language as spoken in Spanish America and Spain than there is between the English spoken in England and the U.S.A., apart from dialects. Many native and old words are included in the Spanish-American vocabulary, but they are easily "picked up" on the spot.

The beginner can be assured that if he knows the material given here, he will rarely find himself embarrassed because of any difference of pronunciation or usage in the language. Chile may present a few problems. In Colombia and Peru very good Spanish is spoken, possibly the best on the Continent. In the River Plate area the language is soft and crooning. Nowhere is it harsh or ill-sounding.

WARNING

The English equivalents for pronunciation given above are makeshifts. Strictly, every letter in Spanish and every combination of letters should be regarded as representing a sound or sounds distinct from any English sounds. Listen to Spanish records, wireless broadcasts, and follow the speaker, imitating exactly the pronunciation: this will give facility in making the sounds. Never be afraid of rolling the r's or pronouncing vowel sounds, especially those accented, with great clarity.

The words *the* and *a* are called articles, the former the definite, the latter the indefinite.

The Definite Article

For *the*, the Spanish equivalents are: **EL** before a masculine noun, **LA** before a feminine noun, **LOS** before a masculine noun plural, **LAS** before a feminine noun plural.

El muchacho, *the boy*	**La muchacha,** *the girl*
Los muchachos, *the boys*	**Las muchachas,** *the girls*

When a feminine noun begins with either **a** or **ha** stressed, then the masculine article **el** is used for euphony. Thus: **el agua,** *the water*; **el hacha,** *the axe*. The plural would be **las aguas,** *the waters*; **las hachas,** *the axes*. Note that **la** is written in full (and not **l'** as in French) before all other feminine nouns beginning with a vowel: **La ambición,** *the ambition*.

There is also a neuter article **Lo** which has no plural. It is used before parts of speech other than nouns to make them nouns: **Lo útil,** *the useful* (**útil** is an adjective). Similarly: **Lo difícil,** *the difficult*. **Lo dicho,** *that which has been said* (**dicho** is past participle of the verb **decir,** *to say*). **Lo pasado,** *the past*. **Lo futuro,** *the future*. **Lo necesario,** *the necessary*. **Lo posible,** *the possible*. The examples given should be memorized as they are of frequent occurrence.

The definite article is used in Spanish with a noun employed in a general sense, or when a noun is used to the fullest extent of its meaning. Thus: **El hombre es como Dios le hizo, y aún peor muchas veces,** *Man is as God made him, and frequently even worse*—Cervantes. **El hombre es mortal,** *Man is mortal*. **Los generales aman la gloria,** *Generals love glory*. **La verdad vale más que las riquezas,** *Truth is worth more than riches*. Excepting as stated below, the usage is more or less the same as in English.

The article is used in Spanish:

(*a*) for the hour: **La una** (**hora** understood), *One o'clock*. **Las dos, las diez** (**horas** understood), *Two, ten o'clock*.

(*b*) for the days of the week: **Abren los domingos a las diez y media,** *They open on Sundays at 10.30*.

(*c*) for the date of the month: **El 25 de Setiembre,** *On the 25th September*.

(*d*) for the year: **El año 1957,** *The year 1957*.

(*e*) before titles: **El Rey Jorge VI de Inglaterra,** *King George VI of England*. **El señor Martínez,** *Mr. Martinez*. The masterpiece of Cervantes is usually referred to as **El Quijote**.

(*f*) before certain geographical names. The following should be noted, as they are frequently met: **El Brasil,** *Brazil*. **El Canadá,** *Canada*. **El Perú,** *Peru*. **El Uruguay,** *Uruguay*.

There is generally a good reason for the use of the article in such cases. Thus: the city of **El Cuzco** in Peru is so called because of its Quechua name (*ccosco*) which means the navel—it was so named because it was the centre of the old Inca Empire. Note also: **El Río de la Plata,** *the River Plate*. **La Coruña, La Mancha, La República Argentina,** *the Argentine Republic*.

The article is often repeated before each noun: **El padre y la madre tienen una casa y**

un jardín, *The father and mother have a house and garden.*

After the prepositions **a** (*to*) and **de** (*of*) the masculine singular of the definite article drops **e**, and is joined with the preposition. Thus: **al,** *to the*; **del,** *of the*. **Al padre,** *to the father.* **Del hermano,** *of the brother.* But: **a los padres,** *to the fathers.* **De los hermanos,** *of the brothers.*

NOTE. The possessive case is expressed in Spanish by the preposition **de**. "*The friend's name*" becomes "*The name of the friend*": **El nombre del amigo.** *My father's hat, the hat of my father*: **El sombrero de mi padre,** etc. One other use of **de** may conveniently be noted here. The material of which an object is made follows the name of the object, the two being connected by **de**: "*a wooden chair*" becomes in Spanish "*a chair of wood*"—**una silla de madera.** **Una casa de madera,** *a wooden house.* And note: **El tonto de Pablo,** *Silly Paul.*

The Indefinite Article

The English indefinite article is expressed as follows:

UN before a masculine noun in the singular.

UNA before a feminine noun in the singular.

Un and **una** have plural forms, **unos, unas,** meaning *some* or *few* in a rather vague sense.

Un hombre, *a man*	**Una mujer,** *a woman*
Unos hombres, *some men*	**Unas mujeres,** *a few women*

Generally the indefinite article is used in Spanish where it is used in English, but note the following exceptions.

Omit the Article: (*a*) when stating a nationality, rank, profession, or trade:

I am a captain, **Soy capitán.** *I am a soldier,* **Soy soldado.** *I am a doctor, lawyer, minister,* **Soy médico, abogado, ministro.**

But use the article when there is an adjective following:

Es un médico muy bueno (or, **Es muy buen médico**), *He is a very good doctor.* *I am an Englishman,* **Soy inglés.** **Ella es española,** *She is a Spaniard.* (But, **El es un argentino de buena familia,** *He is an Argentine of good family.*)

(*b*) The article is omitted in proverbial expressions:

Amigo reconciliado, enemigo doblado, *A reconciled friend is a double enemy.* **Iglesia, o mar, o casa real,** *The church, the sea, or the royal household* (referring to the three careers open to a 17th-century Spanish nobleman).

(*c*) The article is omitted before a noun in apposition:

Londres, capital de Inglaterra, *London, the capital of England.*

NOTE. **Antes de la comida,** *before dinner.* **Después del almuerzo,** *after breakfast.* **En la cuidad, iglesia, escuela,** *in town, church, school.* *I am going to town,* **Voy a la ciudad.**

Sentences to illustrate use of the Articles, their contractions, nouns, and adjectives.

El **artículo precede** *al* **(a + el) nombre.**
The article precedes the noun.
El **suelo de España es rico en minerales.**
The soil of Spain is rich in minerals.
La **capital de España es Madrid.**
The capital of Spain is Madrid.
La **Alhambra está en Granada.**
The Alhambra is in Granada.
Los **recursos** *del* **(de + el) país son grandes.**
The resources of the country are great.
Los **grandes escritores españoles** *del* **siglo XVI.**
The great Spanish writers of the 16th century.
Las **columnas** *de la* **Mezquita de Córdoba.**
The columns of the Mosque of Cordoba.
Las **circunstancias** *del* **caso.**
The circumstances of the case.

From now onwards, and including this Lesson, all the new words must be memorised.

LESSON 2

Nouns, their Genders and Plurals

A NOUN is a word used for naming some *person* or *thing*. There are three genders for Spanish nouns: masculine, feminine, and neuter, but the last is comparatively rare (*see* definite article **LO**, p. 2204).

There is only one rule of gender which may be said to be without exceptions: that the names of men and male animals are masculine, and the names of women and female animals are feminine. Thus:

El padre, *the father*	**La madre,** *the mother*
El toro, *the bull*	**La vaca,** *the cow*

The safest rule for the student to follow is to learn the gender of each noun as it is met. Nevertheless, the following hints will serve as general indications of gender.

I. Nouns ending in **-E, -R, -N, -O, -L** (mnemonic ERNOL) are masculine. Also names of trees, days of the week, months, oceans, rivers, mountains, and all other parts of speech used as nouns.

II. Nouns ending in **-A, -DAD, -IÓN, -TUD** (mnemonic ADADIONTUD) are feminine. Also many nouns in **-UMBRE,** and most names of fruits, cities, and towns.

Examples:

El sol, *the sun*	(ending **-l**)
El cuerpo, *the body*	(ending **-o**)
El cura, *the priest*	(name of a man)
El diente, *the tooth*	(**-e**)
El pan, *bread*	(**-n**)
El calor, *the heat*	(**-r**)

La cabeza, *the head* (-a)
La cantidad, *quantity* (-dad)
La virtud, *virtue* (-tud)
La condición, *condition* (-ión)
La costumbre, *custom* (-umbre)

The phrase **el arte**, *the art*, should be noted. It is masculine in the singular and feminine in the plural: **Las bellas artes**, *the fine arts*.

Never forget gender. The word **Majestad**, *majesty*, is feminine, for example, so we say: **Su Majestad el rey**, *His Majesty the king*; and **Su Majestad la reina**, *Her Majesty the queen*. **Un ángel** is masculine, so we say: **La muchacha es un ángel.**

-O is a characteristic *masculine* ending and **-A** is a characteristic *feminine* ending. But do not forget the first rule of all—names of men are masculine and names of women are feminine. Learn also:

El día, *the day*, **el programa**, *the programme*, **el idioma**, *the language*; **el sistema**, *the system*; **el sud**, *the south*; **la sal**, *the salt*, **la flor**, *the flower*, **la labor**, *the work*, **la calle**, *the street*, **la mano**, *the hand*.

All these exceptions are frequently recurring words and not academic curiosities.

El guía, *the guide*, is the *man* who acts as a guide, **la guía** is inanimate—*a guide book*. **El ayuda** is *the assistant*; **la ayuda** is *assistance, aid*.

The feminine of many nouns, especially those of relationship, is formed by changing the ending **-O** into **-A** or by adding **-A** when the ending is a consonant:

El hijo, *the son*	**La hija**, *the daughter*
El gato, *tom-cat*	**La gata**, *she-cat*

By means of this simple change hundreds of words can be added to one's vocabulary. Other feminine endings for nouns are: **-esa, -isa, -ina.** And **macho** means *male* and **hembra**, *female*. So we say, if we wish to emphasize gender: **El pájaro es hembra**, *the bird is a female* (or, *a hen*).

Plural of Nouns. There are four simple rules for forming the plural; they cover nine-tenths of Spanish nouns and apply equally to adjectives.

I. Nouns ending in an *unstressed* vowel form the plural by adding **-S** to the singular: **El padre**, *the father*. **Los padres**, *the fathers*, etc. **Los padres** also means *parents*.

II. Nouns ending in a *stressed* vowel or a consonant except **-S** or **-Z** add **-ES** to form the plural: **El calicó**, *calico*. Plural: **Los calicoes. El jardín**, *the garden*. **Los jardines.**

III. Nouns ending in **-S** and proper names ending in **-EZ** do not change in the plural. **Los lunes**, *the Mondays*. **Los Rodríguez**, *the Rodriguez*.

IV. Final **-Z** changes to **-CES**. Thus: **la luz, las luces**, *light, lights*. Note that this change preserves the sound of Z. And **El rey, Los reyes**: *King, -s*.

Stress is not affected when the plural is formed: **El árbol**, *the tree*. **Los árboles. El jóven**, *the young man*. **Los jóvenes.** In this last word it is necessary to write the accent, for otherwise **jovenes** would, in accordance with the rules of pronunciation, be wrongly pronounced *joven'es*. Similarly **El cañón**, *the gun*, drops the graphic accent in the plural, which is **Los cañones.**

The plural of **hidalgo**, *nobleman*, is **hijosdalgo**—**hijodalgo** (further abbreviated to **hidalgo**) is short for **hijo de algo**, "*son of something*"; hence the irregular plural. **Carácter**, *character*. Plural **caracteres**.

A list of essential nouns will be found in pp. 2232—2236, and a beginning should now be made of learning not fewer than ten a day.

EXERCISE

Masculine Articles with Feminine Nouns

El **agua del mar es salada.**
Sea water is salt
El **alma es inmortal.**
The soul is immortal.
El **águila de los Andes.**
The eagle of the Andes.
El **ala** *del* **águila.**
The wing of the eagle
BUT NOTE:
Las **aguas de los ríos.**
The waters of the rivers
Las **almas de los niños.**
The souls of the children.
Las **alas de** *las* **águilas.**
The wings of the eagles.

Neuter Article

Lo **valiente** (*that which is brave,—bravery*).
Lo **cortés** (*that which is polite,—politeness*)
Lo **agradable** (*that which is agreeable*).

(and so on, with nearly all adjectives given in the List of Essential Adjectives in pp. 2239—2240).

Definite Article Used in Spanish and not in English

Los **Españoles aman la libertad.**
Spaniards love liberty.
La **adulación es una puerta muy ancha para** *el* **favor;**
Flattery is a very wide door for favour;
pero ningún ánimo noble puede entrar por ella
but no noble soul can enter through it
porque es muy baja.
because it is very low.
La **amistad es una alma que habita en dos cuerpos;**
Friendship is a soul which dwells in two bodies;
un corazón que habita en dos almas.
a heart which dwells in two souls.
El **amor lo toma todo y todo lo da.**
Love takes all and gives all.
El **arte, y en cierto modo** *la* **filosofía, son creaciones de forma.**
Art, and in a certain way philosophy, are creations of form.
Miguel de Cervantes Saavedra nació en Alcalá de Henares.
Miguel de Cervantes Saavedra was born in Alcala de Henares.

Fué bautizado *el* domingo 9 de octubre de 1547 ;
He was baptized on Sunday the 9th of October 1547 ;
y murió *el* 23 de abril de 1616.
and died the 23rd of April 1616.
***El* General Wellington ayudó a los españoles en la**
General Wellington helped the Spaniards in the
Guerra de *la* Independencia.
War of Independence.
***El* Almirante Nelson fué el héroe de Trafalgar.**
Admiral Nelson was the hero of (the battle of) Trafalgar.
" En un lugar de la Mancha . . . vivía un hidalgo . . ."
" In a (certain) village of La Mancha . . . there lived a nobleman . . ."
Estas son las primeras palabras del libro inmortal de Cervantes.
These are the first words of the immortal book of Cervantes.

Contractions

España está limitada *al* norte por el Mar Cantábrico y los
Spain is bounded to the north by the Cantabrian Sea (Bay of Biscay) and the
montes Pirineos que la separan de Francia ; *al* este por el
Pyrenees which separate her from France ; to the east by the
Mar Mediterráneo ; *al* sur por este mar, el estrecho de Gibraltar
Mediterranean Sea ; to the south by this sea, the Straits of Gibraltar
y el Océano Atlántico ; y *al* oeste, por Portugal y el Océano Atlántico.
and the Atlantic Ocean ; and to the west by Portugal and the Atlantic Ocean.

LESSON 3

Adjectives and Numbers

An adjective is a word used to describe the quality of a noun.

In Spanish the adjective agrees in gender and number with the noun and usually follows it. The same rule applies whether one or more adjectives qualify the noun.

Most adjectives end in **-O** in the masculine, **-A** in the feminine, and **-S** in the plural. Thus : **rico** (masculine singular), **rica** (feminine singular), **ricos** (masculine plural), **ricas** (feminine plural).

Un hombre rico, *a rich man.*
Una mujer rica, *a rich woman*
Hombres ricos, *rich men.*
Mujeres ricas, *rich women.*

Adjectives ending in a consonant or in any vowel except **-O** do not change to form the feminine. Adjectives ending in **-án, -ón, -or** add **-a** to form the feminine. Thus :

Un hombre triste, *a sad man.*
Una mujer triste, *a sad woman*
Una cosa útil, *a useful thing.*
Una muchacha holgazana, *a lazy girl* (**holgazán,** masculine)

But adjectives of nationality ending in a consonant form their feminine by adding **-a** :

Un caballero inglés, *an English gentleman.*
Una señora inglesa, *an English lady.*

Adjectives of nationality are used to indicate the language or native of the country concerned. The general rule is that no adjective is written with a capital letter, but as there would be confusion in a sentence where the adjective is used to indicate both a native and a language, then the adjective indicating the native is written with a capital. **El Alemán habla inglés y el Inglés alemán,** *The German speaks English and the Englishman German.*

Adjectives follow the same rules as nouns to form the plural :

Los hombres tristes, *The sad men.*
Las cosas útiles, *The useful things.*

Invariable as regards gender are :
mayor, *greater* , **menor,** *lesser, smaller* , **mejor,** *better* , **peor,** *worse.*

And the following, which have the same meaning in English :
superior, inferior, exterior, interior.

Irregularities

When **grande** indicates importance or is used for impressiveness, and not for mere physical size, it drops the **-de** and is placed before the noun, when it is a singular noun beginning with any consonant but **h** or any vowel but **e** : **un gran amigo,** *a great friend* ; **un amigo grande,** *a big (tall) friend.* **Un gran poeta,** *a great poet.* But : **un grande escritor,** *a great writer.*

Santo, *holy,* becomes **San** when used as a title. **San Pedro, San Juan,** *St. Peter, St. John.* For euphony it is written in full before **DO** or **TO. Santo Domingo,** *St. Dominic* ; **Santo Tomás,** *St. Thomas.*

The following drop **-o** when placed before a masculine noun :
alguno, *some* , **bueno,** *good* ; **malo,** *bad* ; **ninguno,** *no, none* , **primero,** *first* . **uno,** *one* ; **tercero,** *third.* Although these adjectives may be placed after, they are generally placed *before* the noun. **Un buen amigo,** *a good friend* , **El mal tiempo,** *the bad weather* , **ningún padre,** *no father* , **El primer día de Julio,** *the first day of July*

Comparison

	(1)	(2)	(3)
Superiority	**más**	(adjective)	**que,** *more . . . than*
	más	**hermoso**	**que**
	more	*beautiful*	*than*
Inferiority	**menos**	(adjective)	**que,** *less . . . than*
	menos	**feo**	**que**
	less	*ugly*	*than*

In affirmative (but not in negative) sentences use **de** instead of **que** (*than*) before numerals : **Tengo más de tres,** *I have more than three.* **Menos de seis,** *less than six.* But : **No tengo más que tres** (negative sentence).

Equality :	(1)	(2)	(3)
	tan	(adjective)	**como,** *as . . . as*
	tan	**pobre**	**como**
	as	*poor*	*as*

Tan before a noun becomes **tanto,** which is variable : **Yo tengo tanto dinero como Vd.,** *I have as much money as you.*

When **tanto** follows a verb (that is, when there is no adjective, noun, or adverb) and is used in an absolute sense it is followed by **cuanto : tengo tanto cuanto quiero,** *I have as much as I want.* But, **tengo tanto dinero como él,** *I have as much money as he.*

The Superlative

The word **MUY** (*very*) ; the ending **-ísimo** ; and **más, menos,** with the article are the three ways of forming the superlative in Spanish. The ending **-ísimo** (feminine, **-ísima**) is both beautiful and expressive ; but, as its usage is full of pitfalls both of grammar and style, it should be avoided by the tiro.

MUY will be found a most useful word and is of even more frequent occurrence in Spanish than " *very* " is in English. The words **el más** (*the most*) and **el menos** (*the least*) are frequently used to form the superlative, and then the article comes first, then the noun, then **más** (or **menos**), and then the adjective :

El hombre más inteligente, *The most intelligent man*
La mujer menos fea, *The least ugly woman.*

Take the sentence : *John is patient, Charles is more patient, but Robert is the most patient.* This can be translated : **Juan es paciente, Carlos es más paciente, pero Roberto es el más paciente.**

Instead of **el más paciente,** we could say either **muy paciente** or **pacientísimo.** Or, **Carlos es pacientísimo y Roberto es el más paciente.**

Thus the Spanish superlative does *not* correspond exactly to the English. For emphasis **del mundo,** " *in the world,*" may be placed after a superlative : **La mujer más fea del mundo,** *the ugliest woman* (*in the world*).

Irregular Comparison

bueno, *good*	**mejor,** *better*	**óptimo,** *best*
malo, *bad*	**peor,** *worse*	**pésimo,** *worst*
grande, *great*	**mayor,** *greater*	**máximo,** *greatest*
pequeño, *small*	**menor,** *smaller*	**mínimo,** *smallest*

Position of the Adjective

As a general rule the adjective follows the noun, almost invariably when it denotes *nationality, size, shape, colour, weight,* or *any quality of distinction or importance.* When in doubt put it after. Also for emphasis : *My new hat,* emphasis on " new " : **Mi sombrero nuevo.**

But when the quality is a *vague general one* and is *not peculiar to the case in question,* the adjective may come before the noun. *My new hat* (no emphasis on the " new ") : **Mi nuevo sombrero.**

El pobre indio, *the poor devil of an Indian* (i.e. the race).
El indio pobre, *the poor Indian* (the one without money).

Beyond the above rules the beginner ought not to venture. He will best learn where to place the adjective by reading and hearing Spanish.

A list of essential adjectives will be found in pp. 2239–2240. The student should now begin to learn them.

Exercise on Adjectives and Nouns

El **arte es inmortal. Las Bellas Artes por excelencia son :**
Art is immortal. The Fine Arts " par excellence " are :
la **poesía,** *la* **música y** *la* **pintura.**
poetry, music, and painting.
El **programa** *del* **día comprende el estudio** *del* **idioma español.**
The programme of the day includes the study of the Spanish language.
En *el* **norte y en** *el* **sur (o sud), en** *el* **este y en** *el* **oeste,** *el*
In the North and in the South, in the East and in the
sistema es el mismo.
West, the system is the same.
El **guía abrió** *la* **guía para consultarla.**
The guide (man) opened the guide (book) to consult it.
En España y en la América Latina hay muchísimos pueblos,
In Spain and in Latin America there are (very) many villages,
ciudades, ríos, islas, etc., que tienen nombres de santos
cities, rivers, islands, etc., which have names of saints
Por ejemplo, *San* **Sebastián, famosa ciudad en la costa del**
For example, *San* Sebastian, *a* famous city on the coast of
Cantábrico ; *Santa* **María es el nombre de innumerables pueblos**
the Cantabrian (sea) ; *Santa* Maria is the name of innumerable towns
y villas de España ; Santiago, ciudad catedral de la provincia
and villages of (in) Spain ; Santiago, *a* cathedral city
de la Coruña.
of (in) the province of Corunna.
Gaspar Núñez de Arce fué un poeta inspirad*ísimo.*
Gaspar Nuñez de Arce was a *most* inspired poet.
Don Emilio Castelar fué un político cult*ísimo.*
Don Emilio Castelar was a *most* cultured politician.
Quevedo fué un autor satírico interesant*ísimo.*
Quevedo was a *most* interesting satirical author.

Irregular Comparison

El vino de Aragón es *bueno* ; **el de Rioja es** *mejor* ;
The wine of Aragon is *good* ; that of Rioja is *better* ;
el de Jerez es *óptimo* (*el mejor*).
that of Jerez (Sherry) is *best.*
Madrid eas *grande* ; **Pris es** *mayor* ; **Londres es** *la mayor*
Madrid is *large* ; Paris is larger ; London is the
de las ciudades del mundo.
largest of the cities of the world.
Las diferencias de temperatura en Inglaterra son *grandes* ,
The differences in temperature in England are *great* ,
en Castilla son *mayores.* **La temperatura** *máxima* **del invierno pasado fué**
in Castile are *greater.* The highest temperature of last winter was
de 20 grados sobre cero, y la *mínima* **de 4**
(of) 20 degrees above zero, and the lowest (of) 4

bajo cero registradas por el termómetro Centigrado.
below zero registered by the Centigrade thermometer.

Position of Adjectives

Un joven delgado, huesudo, pálido.
A young man, thin, bony, pale.
Un clérigo alto, de rostro pálido y redondo . . . conojos
A tall clergyman, with a pale, round face . . . blue
azules y mirada vaga.
eyes and (a) vague look.
Un joven gordo, muy gordo, rubio . . .
A fat, very fat, and fair young man . . .
Un hombre bajo, gordo, de faz amoratada, ojos saltones
A short (low) man, fat, livid of face, with darting,
y oblicuos, el cabello blanco, y el bigote entrecano,
oblique eyes, white hair, and greyish moustache,
duro y erizado como las púas de un puercoespin. Los
hard and bristling like the spines of a porcupine. *His*
labios gruesos y sinuosos . . . Podria tener unos sesenta
lips thick and sinuous . . . He might have been about
años, más bien más que menos.
sixty years (old), rather more than less.

From *La Espuma* by Palacio Valdés

NUMBERS

Cardinal Numbers

1	**uno, una**	21	**veinte y uno, una**[1]
2	**dos**	22	**veinte y dos**
3	**tres**	23	**veinte y tres**
4	**cuatro**	24	**veinte y cuatro**
5	**cinco**	25	**veinte y cinco**
6	**seis**	26	**veinte y seis**
7	**siete**	27	**veinte y siete**
8	**ocho**	28	**veinte y ocho**
9	**nueve**	29	**veinte y nueve**
10	**diez**	30	**treinta**
11	**once**	31	**treinta y uno,**[1] etc
12	**doce**	40	**cuarenta**
13	**trece**	50	**cincuenta**
14	**catorce**	60	**sesenta**
15	**quince**	70	**setenta**
16	**diez y seis**[1]	80	**ochenta**
17	**diez y siete**	90	**noventa**
18	**diez y ocho**	100	**ciento, cien**
19	**diez y nueve**	101	**ciento y uno, ciento uno**
20	**veinte**	200	**doscientos, -as**

300, **trescientos (-as)**; 400, **cuatrocientos**; 500, **quinientos**; 600, **seiscientos**; 700, **setecientos**; 800, **ochocientos**; 900, **novecientos**; 1,000, **mil**; 100,000, **cien mil**; 1,000,000, **un millón**.

[1] In Spanish America (and in parts of Spain also) it is customary to write these compounds as one word: **dieciseis, diecisiete, veintiuno, veintidós, treintiuno**, etc

Uno becomes **un** or **una** if a noun follows: **un caballo,** *a* or *one horse.*

Ciento changes to **cientos, cientas** to agree with the noun following: **cuatrocientas mujeres.** When **ciento** comes immediately before a noun or **mil** (a thousand) it drops the final syllable: **cien hombres,** 100 *men.* **Cien mil pesos,** 100,000 *pesos.* **Uno** is not used before **ciento** and **mil: mil doscientos,** 1,200; **ciento cincuenta,** 150.

Above nine hundred count by thousands, with the odd hundreds following: 1933, **mil novecientos treinta y tres.**

Ordinals

Primero, *first.* **Segundo,** *second.* **Tercero,** *third.* **Cuarto,** *fourth.* **Quinto,** *fifth.* **Sexto,** *sixth.* **Séptimo,** *seventh.* **Octavo,** *eighth.* **Noveno** or **nono,** *ninth.* **Décimo,** *tenth.* They are abbreviated thus: 1°, 2°, 3°, etc.

There is no need to learn more than 1-10 at this stage. The ordinal numbers above ten are generally replaced by cardinals, except in old, dignified, or ironical style. Thus we say:

el siglo veinte, *the twentieth century.* **La página diez y nueve,** *the nineteenth page* (or *page nineteen*).

Ordinals should be regarded as adjectives, agreeing in gender and number with the noun or nouns which follow:

Los primeros dias, *the first days.* **La segunda clase,** second class. **Primero** and **tercero** drop the **-o** before a noun masculine singular **El primer hombre,** *the first man.* **El tercer año,** *the third year.* Also when separated from their noun by an adjective only: **El primer buen dia,** *the first good day.* But not when other parts of speech come between: **El primero** (or **tercero) de mis amigos,** *the first (third) of my friends.*

Miscellaneous

Una vez, *once.*
Dos veces, *twice.*
Tres veces, cuatro veces, etc.
Doble, triple, *double, triple.*
Cuádruplo, *quadruple.*
La mitad, *the half* (*n.*).
Medio, *half* (*adj.*).
Una hora y media, *an hour and a half*
Un tercio, *one third.*
Un cuarto, *one quarter.*
Un par, *a couple.*
La decena, *half a score*
Una docena, *a dozen.*
Una veintena, *a score.*
Un centenar, *a hundred.*
Un millar, *a thousand*
Más o menos, *more or less.*
Cosa de, *about, approximately.*
O cosa asi, *or thereabouts.*

Ocho dias, *a week.*
Quince dias, *a fortnight.*
¿Cuantos años tiene Vd.? *How old are you?*
Tengo veinte años, *I am 20 years old.*
A la edad de, *at the age of.*
¿Qué hora es? *What o'clock is it?*
Es la una, *It is one o'clock.*
Es la una y media, *1.30.*
Son las dos, *It is two o'clock.*
Son las dos y media, *2.30.*
Son las dos y cinco minutos, *Five past two.*
Las dos y cuarto, *2.15.*
Las tres menos cuarto, *2.45*
Son cerca de las tres, *Almost three o'clock.*

Different Usage in Spanish

It is important to remember that age is expressed by **tener** and time by **ser,** as in the examples given above (which should be thoroughly mastered). Use ordinals for kings, popes, etc., up to ten; and cardinals after ten: **Felipe segundo,** *Philip II.* **Pio nono,** *Pius the ninth.* **Alfonso trece,** *Alfonso XIII.*

El primero de Julio, *the first of July.* **El 2 de Julio.** As these two examples show, days of the month are expressed by cardinal numbers, excepting the first. In dating letters it is customary to leave out the article: **Madrid, 7 de Abril de 1957.** *He will come on the 20th,* **Vendrá el día veinte.** *On the 24th of August,* **El día veinticuatro de Agosto.** *To ask the date, say:* **¿A cuántos estamos hoy?** Reply: **A once,** *It is the eleventh.* **¿Qué fecha será**

mañana ? *What will the date be tomorrow ?* Reply : **El cinco, seis,** etc.

On Monday, Tuesday, etc., is expressed simply by the words **el lunes, martes,** etc. **Vendré el lunes,** *I will come on Monday.*

NOTE. The verb **DAR** (*to give*) is used for the *striking* of the hour **Ha dado la una,** *It has struck one.* **Han dado las dos,** *It has struck two.* "Next" in expressions of time is translated by **que viene** (which is coming). **La semana que viene,** *next week.* **El mes que viene,** *next month.* For days of the week use **próximo: el próximo lunes,** *next Monday* (or **el lunes próximo**). **El año que viene. La semana pasada,** *last week.* **El año pasado,** *last year.*

Measurement · Use **TENER** followed by the noun or adjective of dimension followed by **de.** Thus **Esta casa tiene 90 pies de largo y 50 de ancho,** *This house is 90 feet long by 50 wide.* **La casa tiene 80 pies de alto,** *the house is 80 feet high.* **Alto,** *high.* **Largo,** *long.* **Ancho,** *broad, wide.* **Profundo,** *deep* (also **hondo**). **Grueso,** *thick.*

EXERCISE ON NUMBERS

NOTE. *In these Exercises the English does not always fall under the Spanish equivalent ; the student's skill is thereby better tested.*

En la Escuela (At School)

Hoy es martes, catorce de septiembre de 1957. El curso
Today is Tuesday, the fourteenth of September, 1957.
escolar principió hace una semana. Este curso hay *más* **alumnos**
The school course (term) began a week ago This course (term)
que **nunca en la escuela. Hay** *más de* **doscientos. Entramos en**
there are more students than ever (never). There are more than two hundred.
la escuela a las nueve de la mañana . tenemos un descanso entre
We enter (in the) school at nine (of the)
las **diez y media y** *las* **once menos cuarto y salimos para tomar**
in the morning ; we have a rest between half past ten and a quarter to eleven
el almuerzo a *las* **doce. Regresamos a la escuela a** *las* **dos ;**
and we leave to take (the) lunch at twelve
después vamos a jugar un poco de tres y cuarto a tres y media ;
We return to (the) school at (the) two ; after (then) we go to
finalmente salimos a *las* **cuatro y media.**
play a little from a quarter past three to half past three ; finally we leave at half past four.

Tenemos que estudiar principalmente aritmética, historia
We have to study principally arithmetic, history and
y geografía. En la clase de arithmética hemos aprendido la
geography. In the class of arithmetic we have learned (the)
adición o suma, la substracción o resta, la multiplicación
addition, (the) subtraction, (the) multiplication
y la división. En España se usa el sistema métrico decimal.
and (the) division. In Spain is used the decimal metric system.
La unidad monetaria es la peseta, que se divide en cien
The monetary unit is the peseta, which is divided into one
céntimos. Así, todas las operaciones de aritmética referentes a pesos,
hundred "centimos" Thus, all (the) operations of arithmetic relating to weights,
medidas y monedas, son muy fáciles. Por ejemplo · ¿ Cuánto
measures and money are very easy. For example How much
valdrían doscientos cuarenta y seis metros y medio de
would be worth two hundred and forty-six and (a) half
tela a ocho pesetas sesenta céntimos el metro ? Multipli-
metres of cloth at eight pesetas sixty centimos *the* (a) metre ?
camos el número de metros por el número de pesetas, separamos
We multiply the number of metres by the number of pesetas,
las dos cifras decimales que intervienen en la operacion
separate the two decimal figures which intervene in the
y tenemos el resultado inmediatamente. Este es : dos mil
operation and we have the result immediately. This is :
ciento diecinueve pesetas con noventa céntimos. Así :
two thousand one hundred and nineteen pesetas (with) ninety centimos. Thus
246,5 × 8,6 = 2.119,90
¡Cuánto más complicada sería una operación análoga con
How much more complicated would be an analogous operation
medidas y monedas de Inglaterra ! ¡ Digamos, 246 yardas,
with measures and money of England ! Let us say 246 yards,
2 pies, 5 pulgadas, a 4 chelines y 11 peniques la varda !
2 feet 5 inches at 4 shillings and 11 pence *the* (a) yard !

LESSON 4

Pronouns

A PRONOUN is a word used instead of a noun or a noun equivalent. This is a most important lesson and must be known thoroughly, as the pronouns are of frequent recurrence.

In the list on the opposite page the subject pronouns answer the question *Who acted?* The direct object pronouns answer the question: Who or what was the direct or primary recipient of the action ? The indirect object pronouns answer the question : Who or what was the indirect or secondary recipient of the action ? Thus : *I will tell it to him.* I, is subject ; IT. is direct object ; (to) HIM, is indirect object. If this list is committed to memory, and the difference between *direct* and *indirect* object kept clearly in mind when pronouns have to be used, all will be well.

PERSONAL PRONOUNS

I	II	III
Subject Pronouns	*Direct Object Pronouns*	*Indirect Object Pronouns*
YO, *I*	**ME,** *me*	**ME,** *to me*
TÚ, *thou*	**TE,** *thee*	**TE,** *to thee*
ÉL, *he*	**LO, LE,** *him*	**LE,** *to him*
ELLA, *she*	**LA,** *her*	**LE,** *to her*
ELLO, *it*	**LO,** *it*	**LE,** *to it*
NOSOTROS, *we*	**NOS,** *us*	**NOS,** *to us*
VOSOTROS, *you, ye*	**OS,** *you*	**OS,** *to you*
ELLOS, *they (m.)*	**LOS,** *them*	**LES,** *to them*
ELLAS, *they (f.)*	**LAS,** *them*	**LES,** *to them*
NOTE WELL.		
VD., *you*	**LO, LA, a Vd.,**	**LE, a Vd.,** *to you*
VDS., *you (pl.)*	**LOS, LAS, a Vds.,** *you*	**LES, a Vds.,** *to you*

Vd., Vds. (or **Ud., Uds.**) abbreviations for **Usted, Ustedes.** Now turn to pp. 2230–2231 and learn the difference between **TÚ, VOSOTROS,** and **Vd.**

Never forget gender. Hence, the English word *it* may be translated by **él, ella, ello,** and of the three only **ello** is a pure neuter in Spanish.

Thus: **Aquí está mi casa. Ella es muy cómoda.** *Here is my house. It is very comfortable.*

It will be observed that **él** has two forms **lo** and **le** to represent the direct object. Use **le** when referring to persons and **lo** when referring to things.

Él le llama, *He calls him.* **Él lo llama,** *He calls it.*

Ello is a true neuter: **Ello podrá ser verdad, pero no lo creo,** *It may be the truth, but I do not believe it.* The **Ella** or **Ello** can be omitted, i.e. taken for granted: this is much more usual in conversation.

Reflexive Pronouns

Reflexive pronouns are used when a person (or thing) does something to himself, herself (or itself): *I wash myself. He hides himself.* "*Myself*" and "*himself*" are reflexive pronouns. The Spanish reflexive pronouns are:

ME, *myself*
TE, *thyself*
NOS, *ourselves*
OS, *yourselves*

And now we come to a word which must be watched because of its manifold meanings. **SE** is the third person reflexive pronoun for *all genders, singular* and *plural*, and for **Vd.,** *and its plural* **Vds.** Thus:

Himself, herself, itself, oneself
Themselves (all genders)
Yourself
Yourselves
translate by **SE**

El se llama, *He calls himself.*
Ella se engaña, *She deceives herself.*
Ellos se conocen, *They know themselves.*
Vd. se admira, *You admire yourself.*
Vds. se levantan, *You get up* (pl.).

Reflexive verbs are common in Spanish, hence these reflexive pronouns are in great demand (*see* p. 2216).

Use of Personal and Reflexive Pronouns

As will be seen later, the Spanish verb is inflected for changes of person (*see* Lesson 5), and therefore it is not always necessary to use a subject personal pronoun with it. **Tengo** can only mean "*I have,*" and **estoy** can only mean "*I am.*" So it is necessary to say **Yo tengo, yo estoy** —unless for emphasis. But **tiene,** the third person singular of the present tense, may mean *he, she,* or *it has,* or *you have* (**Vd.**). It is therefore advisable to put a pronoun with it, unless there can be no doubt as to its meaning.

Object and reflexive pronouns precede the verb except: (*a*) the infinitive and the present participle, with which they are joined, and (*b*) the imperative affirmative, with which they are also joined.

Tenerlo, *to have it.* **Teniéndolo,** *having it*
¡Téngalo! *Take it!*
Lavarse las manos, *To wash one's hands*

Four Rules of Position

I. When two object pronouns are required direct and indirect—as in the sentence, "He gives it to me," the order of the object pronouns in Spanish is the reverse of the English order. Thus:

English: *He gives it to me.* (1) (2)
Spanish: **El me lo da.** (2) (1)

II. **SE** in all its meanings precedes any other object pronoun or pronouns. **Se lo diré,** *I will tell it to him.*

III. **TE** and **OS** precede all pronouns except **SE.** **Te lo diré,** *I will tell it to thee.*

IV. **LE, LO, LA, LES, LOS, LAS** take the last place before the verb: **Yo se lo doy,** *I give it to him.*

Pronouns with Prepositions

Certain pronouns when preceded by a preposition change their form slightly: **me** becomes **mí, te** becomes **ti,** and **se** becomes **sí.** The preposition **con** (with) makes **conmigo, contigo,** and **consigo** for *with me, with thee, with him, her, it, them, etc.* Thus:

Para mí, *for me.* **Sin ti,** *without thee.* **Con él,** *with him.* **Con nosotros, nosotras,** *with us.* **Por ellos,** *by them.* **A ella,** *to her.*

If the person has already been designated, always use **sí** instead of **él, ella, ellos, ellas, Vd., Vds.** **Ellos hablan de sí,** *They are speaking of themselves.*

When two object pronouns are in the third person, then, in order to avoid repetition of the letter L, the first is changed to **SE**. Instead of saying **Le lo di,** *I gave it to him*, we must say, **Se lo di.** Similarly, **Dígaselo,** *Tell it to him.*

When there is ambiguity or doubt, then it is advisable to add a **él, a Vd.,** etc. **Se lo avisaré a Vd.,** *I will let you know about it* (*tell it to you*).

Examples of the use of pronouns :

Vd. me habla, *You speak to me.* **Hablo de mí,** *I speak of myself.* **Yo le he hablado,** *I have spoken to her.* **Yo les digo,** *I tell them.* **Les escribiré,** *I will write to them.* **Los tengo,** *I have them.* **Me parece probable,** *It seems to me probable.* **Él me ha comprado las manzanas,** *He has bought the apples from me.* **Yo me he ofrecido a él como amigo,** *I have offered myself to him as a friend.* **Le digo a Vd.,** *I tell you* (emphatic). **¿ Se ha lavado Vd. las manos ?** *Have you washed your hands ?*

The word **mismo** means "same" and also "self." It agrees with and may be placed after any personal pronoun for emphasis.

Yo mismo, *I myself.* **Nosotros mismos,** *We ourselves.* **Ellas mismas,** *They themselves* (*f.*). **Ella misma,** *She herself.* **Yo mismo les escribiré,** *I will write to them myself.*

It should not be confused with reflexives.

LO is often used as an equivalent for *so, one, it,* in such sentences as :

Él está enfermo, pero no lo parece, *He is ill, but does not appear so.* **O es médico, o va a serlo,** *Either he is a doctor, or he is going to be one.*

Relatives and Interrogatives

A relative pronoun is one which connects the noun or pronoun to which it refers with the part of the sentence which follows. Thus : *The man whom I know. The house that Jack built. Whom* and *that* are relatives.

The relative pronouns must *always* be expressed in Spanish, and are :

Quién, *who*	**El cual,** *which*	**Que,** that
Cuyo, *whose*	**Cuanto,** *as much*	

Que is invariable. All the other relatives are variable and follow the same rules for inflexions as adjectives. Thus :

Quien, quienes
El cual, la cual, los cuales, las cuales
Cuyo, cuya, cuyos, cuyas

Que may refer either to persons or things. **Quien** refers only to persons.

El hombre que viene es mi amigo, *The man who comes is my friend.* **Quien viene es mi amigo,** *He who comes is my friend.*

El cual is used for persons and things, and is a more accurate relative than **que** or **quien.** It is generally used after a preposition.

Han llegado mis dos hermanos, con los cuales Vd. debe tratar, *My two brothers have arrived, with whom you must deal.*

Cuyo is the possessive, and may be used with persons or things :

El padre cuyos hijos están aquí. *The father whose sons are here.* **La llave cuya pérdida me ha costado tanto,** *The key of which the loss has cost me so much.*

All the above relatives are used as interrogatives, but then they must be written with the graphic accent :

¿ Quién ? *Who ?* **¿ Cuál ?** *Which, which one* (*of several*) *?*

¿ Qué ? *What ?* **¿ Cúyo ?** *Whose ?* **¿ Cuánto ?** *How much ?*

¿ Quién está hablando ? *Who is speaking ?*
¿ A quién habló Vd. ? *To whom did you speak ?*
¿ Qué le falta ? *What are you short of ?*
¿ Cuál caballo ? *Which horse ?*
¿ Cuáles son sus ideas ? *What are your ideas ?*
¿ Cúya es esta casa ? *Whose is this house ?* (*Or,* **De quién...,** which is more modern).
¿ Cuánto dinero tiene él ? *How much money has he ?*

Qué and **cuánto** (**cuán** before adjectives) are used in exclamations :

¡ Qué muchacha tan hermosa ! *What a beautiful girl !* **¡ Cuán rico es !** *How rich he is !* **¡ Cuántas veces !** *How often . . . !*

Demonstrative Pronouns

	Singular		*Plural*	
	Masc.	*Fem.*	*Masc.*	*Fem.*
This :	**este**	**esta**	**estos**	**estas**
That :	**ese**	**esa**	**esos**	**esas**
That :	**aquel**	**aquella**	**aquellos**	**aquellas**

Este is used for something close at hand.

Ese is for something a little more remote.

Aquel is for something remote from both speakers (*yonder*).

Éste, ése, aquél are also used alone, and then they take the graphic accent. **Este hombre y aquél,** *This man and that one.*

Este es mi libro, *This is my book.*
Ese libro que Vd. tiene, *That book you have.*
Aquel libro que tiene mi hermano, *That book which my brother has.*
Él vive en aquella ciudad, *He lives in that city.*

Eso, esto, and **aquello** are used for the neuter, but in the singular only :

¿ Quién ha dicho esto ? *Who has said that ?* **Eso es,** *That's it.* **Aquello no importa,** *That does not matter.*

They always refer to an abstract idea or to some remark.

Possessive Adjectives and Pronouns

Adjectives	*Pronouns*
mi (*pl.* **mis**), *my*	**mío (mía, míos, mías),** *mine*
tu (tus), *thy*	**tuyo,** *thine*
su (sus), *his, her, its*	*suyo, his, hers its*
nuestro (-a, -as), *our*	**nuestro,** *ours* } **-a, -os, -as**
vuestro (-a, -os, -as), *your*	**vuestro,** *yours*
su (sus), *their*	**suyo,** *theirs*

Su, sus, and **suyo,** it should not be forgotten, are also used as possessive adjectives and pronouns corresponding to **Vd., Vds.** But in case of ambiguity, it is better to use **de Vd., de Vds., de él, de ella,** etc.

The possessive adjectives (or adjectival pronouns) **mi, tu, su, nuestro, vuestro, su,** and their plurals are generally placed before the

noun. The forms **mío, tuyo,** etc., can be placed after for emphasis, with an article before the noun. Thus:

Mi padre, *my father*.
El sombrero mío, *my hat.*

Mío, tuyo, suyo are also true pronouns—that is, they can replace nouns:

El mío, *mine.* **El suyo,** *his, hers*

Este sombrero es mío. *This hat is mine.*

Possessive Adjectives and Pronouns in Spanish agree in Gender and Number with the object possessed.

Mis sombreros, *my hats* **Esos sombreros son míos,** *those hats are mine.*

Las plumas son suyas, *the pens are his, hers.*
Las plumas son de él, *the pens are his.*
Mi querido amigo, *my dear friend (masc.).*
Querida amiga mía, *my dear friend (fem.).*
Él es buen amigo mío, *He is my good friend.*
Ella es buena amiga mía, *She is my good friend.*

Miscellaneous

A number of very useful words are like adjectives and pronouns in that they can be used either as adjectives with a noun, or as pronouns instead of a noun or nouns.

Todo, -a, -os, -as, *All, everyone*
Mucho, -a, -os, -as, *Much, many*
Poco, -a, -os, -as, *Few, little*
Entero, -a, -os, -as, *Whole, entire*
Solo, -a, -os, -as, *Only alone*
Único, -a, -os, -as, *Unique, only*
And the invariable word **cada,** *each.*

Examples

Toda la semana, *all the week.* **Todo el día,** *all the day.* **Lo he visto todo,** *I saw all of it.* **Lo haré todo,** *I will do it all.* **Todo lo que he hecho,** *all that I have done.* **Vds. todos,** *all of you.* **Todos ellos, Ellas todas,** *all of them* **Es la verdad, todo.** *It is the truth, all of it.* **Vinieron todos,** *they all came.* **Todo el mundo,** *everybody.*

Con mucho gusto, *with much pleasure.* **Mucho** *is the word for "very" with verbs.* **Me gusta mucho,** *I like it very much.* **¿Tiene mucha suerte, no es verdad?** *He is very lucky, is he not?* **Mucha,** *Very.*

Un poco de leche, *a little milk.* **Hay poca luz en esta casa,** *There is little light in this house.* **¿Tiene Vd. mucho dinero?** *Have you much money?* **No, Señor, muy poco,** *No, Sir, very little.*

Estoy solo, *I am alone.* **Yo sólo,** *I only.* **Mi hermano único,** *my only brother* **Mi hermano solo,** *my brother alone.*

Sólo is sometimes used instead of **solamente** the adverb. But note that it is then written with an accent. **Sólo tengo un cigarillo,** *I have only one cigarette.*

Una cajita para cada veinte huevos, *A little box for each score of eggs.* **Cada uno de mis hermanos,** *each one of my brothers.* **La noche entera or toda la noche,** *all the night.* **Una semana entera,** *a whole week.*

Note also the following: **Otro,** *other.* **Alguno,** *some.* **Ambos,** *both.* **Varios,** *several.* **Propio,** *own, very own.* **Cierto,** *certain.* All these are variable. **Otro, otra, otros, otras,** etc.

Él, la, lo, los, las demás, *the rest, the others* **Tal (tales),** *such.* **Semejante,** *similar.*

Alguna cosa and **algo** (*something*), **ninguna cosa, nada** (*nothing*), are interchangeable.

No me gusta ninguna cosa, *Nothing pleases me.* **Nada me gusta,** *Nothing pleases me.*

All these words recur frequently, and must be known.

Exercise on Pronouns

Las lecciones de historia *nos gustan* **mucho.** (The) lessons of History please us (very) much. We like the history lessons very much.

(Note the peculiar construction of this verb **GUSTAR,** *to like, to be pleasing.* The subject and object of the English sentence become object and subject respectively in the Spanish sentence. Thus: *I like it* = *It is pleasing to me*= *It pleases me*=**Me gusta.**)

Nuestro profesor explica las lecciones de manera
Our teacher explains (the) lessons in a very interesting
muy interesante. Sabemos que la Península Ibérica estuvo
manner We know that the Iberian Peninsula was
habitada en un principio por celtas y luego por iberos,
inhabited in the beginning by Celts and then by Iberians
de los que resultó la raza de los celtíberos. Vinieron
from which resulted the Celtiberian race There came
a España, y se establecieron en ella, otros pueblos:
to Spain and established themselves in it, other peoples:
fenicios, griegos, cartagineses y romanos. Estos últimos
Phoenicians, Greeks, Carthaginians and Romans The last
la dominaron durante seis siglos. Los españoles recibieron
dominated it during six centuries. The Spaniards received
de los romanos la lengua latina que fué la madre de la
from the Romans the Latin language which was the mother
castellana. Después de los romanos dominaron a España
of the Castilian (language) After the Romans the Goths
los godos durante los siglos quinto, sexto y séptimo.
dominated Spain during the fifth, sixth and seventh centuries.
En el año 711 (setecientos once) invadieron la Península
In the year seven hundred and eleven invaded the Peninsula
los árabes, los cuales permanecieron en España hasta
the Arabs, who remained in Spain until in one thousand
que, en 1492 (mil cuatrocientos noventa y dos) fueron
four hundred and ninety two they were definitely
definitivamente expulsados por los famosos Reyes Católicos.
expelled by the famous Catholic Sovereigns
Fueron éstos Isabel I (primera) de Castilla y Fernando V (quinto)
These were Isabella *the* first of Castile and Ferdinand *the* fifth
de Aragón. Durante los setecientos ochenta años
of Aragon. During the seven hundred and eighty
de dominación árabe, los españoles fueron poco a poco
years of Arab domination, the Spaniards went on little by little
reconquistando la península desde diversas partes de
reconquering the Peninsula from various parts of
España, formándose así varios reinos independientes.
Spain, forming thus various independent kingdoms.
Héroe nacional de la reconquista fué Don Rodrigo Díaz
National hero of the reconquest was Don Rodrigo Díaz
de Vivar, llamado el Cid Campeador, quien llegó a
de Vivar, called the Cid (Campeador), who arrived to (succeeded in)
conquistar Valencia, enviando las llaves de esta plaza
conquering Valencia, sending the keys of this place (town)

al Rey de Castilla Fernando VI (sexto).
to the King of Castile, Ferdinand *the* sixth

El "*Poema del Cid*" es la primera obra literaria
The "Poem of the Cid" is the first literary work

escrita en castellano. No se sabe por quién fué escrito;
written in Castilian. It is not known by whom it was written,

tampoco cuándo, aunque se cree que entre 1140 (mil ciento cuarenta)
neither when, although it is believed to be between one

y 1157 (mil ciento
thousand one hundred and forty and one thousand one

cincuenta y siete). El verdadero fundador de la lengua
hundred and fifty-seven. The true founder of the Castilian

castellana fué el Rey de Castilla Alfonso X (diez)
language was the King of Castile Alphonso *the* tenth

llamado el Sabio. Vivió entre 1220 (mil doscientos veinte)
called the Wise. He lived between one thousand two hundred

y 1284 (mil doscientos ochenta y cuatro).
and twenty and one thousand two hundred and eighty-four.

En la edad moderna fueron monarcas notables de España:
In the Modern Age were notable monarchs of Spain:

Carlos I (Primero), quien fué también Carlos V (Quinto) de
Charles the First, who was also Charles the Fifth of

Alemania; Felipe II (Segundo), su hijo, quien fundó el
Germany; Philip the Second, his son, who founded the

grandioso monumento de El Escorial: Felip V (Quinto),
grandiose monument, the Escorial; Philip the Fifth,

primero de los Borbones: Carlos IV (Cuarto), en cuyo
first of the Bourbons, Charles the Fourth, in whose

reinado tuvo lugar la batalla de Trafalgar; su hijo, el
reign took place the battle of Trafalgar; his son, the

funesto Fernando VII (Séptimo), abuelo de Alfonso XIII
dismal Ferdinand the Seventh, grandfather of Alphonso the

(trece). Este rey ha sido *el último* de los monarcas españoles.
Thirteenth. This king was the last of the Spanish monarchs.

LESSON 5

Auxiliary, Regular, and Reflexive Verbs

A VERB is a word used for saying something about some person or thing.

Compared with the verbs of some other European languages those of Spanish are straightforward. It is unnecessary to know all the parts of even the regular verbs, unless the student aims to become an expert translator. As for the 900 irregular Spanish verbs, only about 100 occur frequently, and of these only the most useful parts will be given. It is, however, necessary for the student to realize at the outset that there is not a line in the treatment of the verb given in these pages which he can afford to neglect. What is given must be known thoroughly—so thoroughly that the part of a verb required comes without hesitation to the mind.

Parts of the Verb which Must be Known

(*a*) The *Infinitive*, i.e. "that part of a verb which names the action, without reference to any doer, and is therefore not limited by person or by number." Thus: **Comprar,** *to buy*; **Vender,** *to sell*; **Vivir,** *to live.*

(*b*) The *Present Tense*, which represents the English forms *I—*, *I do —*, *I am—ing.* Thus: **Yo compro,** *I buy, I do buy*, or, *I am buying.*

(*c*) The *Past Tense Definite*, which corresponds to the English Simple Past, or *I did—*. Thus: **Yo compré,** *I bought*, or, *I did buy.*

(*d*) The *Future Tense Simple*, which represents the English *I shall—*. Thus: **Yo compraré,** *I shall buy.*

(*e*) The *Past Participle*, which is used to form compound tenses, and often as an Adjective. Thus: **Yo he comprado,** *I have bought.*

The Infinitive of all Spanish verbs has one of the three endings: **-AR**, **-ER**, or **-IR**. Thus: **Comprar,** *to buy*; **Vender,** *to sell*; **Vivir,** *to live.* All verbs ending in **-AR** are conjugated similarly to **comprar**: all in **-ER** similarly to **Vender**: all in **-IR** similarly to **Vivir**. Those which do not follow the models of these verbs are called "Irregular," and their essential parts will be found in pp. 2219 2221.

Formation of Tenses

For purposes of reference a complete table of the inflexions of all regular verbs is given in p. 2217.

Every part of a regular verb can be formed from this table, the auxiliaries being used for compound tenses.

To form any Tense, simply add the Inflexions in the Table to the "Stem" of the Verb. This "Stem" is found by removing the infinitive ending. Thus **Compr-, Vend-, Viv-,** *are the Stems of* **Comprar, Vender,** *and* **Vivir.** *In the Future Indicative and Conditional, the endings in the Table are added to the Full Infinitive.*

Examples

The Present of **comprar** is: **compro, compras, compra, compramos, compráis, compran.**

The Future of vender is: **Vendere, venderás, venderá,** etc The Past Definite of vivir is: **Viví, viviste, vivió,** etc. The conditional would be: **compraría,** etc.

The Imperfect tenses of the three are: compraba, vendía, vivía, etc.

IMPORTANT NOTE. Pronouns (subject) may be omitted where the inflexion of a verb clearly indicates the person. The pronoun should, however, always be used for emphasis. Thus: **Yo compro,** *It is I who buy.*

It will be noticed that, excepting the infinitive and the two forms built upon it (future and conditional) the inflexions of **-ER** and **-IR** verbs differ only in the 1st and 2nd persons plural indicative present and in 2nd person plural of the imperative

What Spanish Tenses Represent in English

Let us take the verb **Amar,** a regular verb, and, in the first person of each tense, the translation into an English equivalent would be:

Infinitive: **Amar,** *to love*
Present Participle: **amando,** *loving*
Past Participle: **amado,** *loved.*

Indicative:

Present Tense: **amo,** *I love*
Imperfect: **amaba,** *I was loving.*
Past Definite: **amé,** *I did love, I loved.*
Future: **amaré,** *I shall love*
Conditional: **amaría,** *I should love*
Imperative: **ama (tú),** *love thou!* **amad,** *love!*
(**Amad a vuestros enemigos,** *Love your enemies.*)

Subjunctive

Present: **ame,** *that I love*
Imperfect: **amase,** *that I loved*
Future: **amare,** *that I shall love.*

Compound Tenses

Perfect: **(Yo) he amado,** *I have loved*
1st Pluperfect: **había amado,** *I had loved*
2nd Pluperfect: **hube amado,** *I had loved*
Future Perfect: **habré amado,** *I shall have loved*
Past Conditional: **habría amado,** *I should have loved*

And similarly, the *Subjunctive*

Perfect: **Que yo haya amado,** *that I have loved.*
Pluperfect: **hubiese amado,** *that I had loved*
Future: **hubiere amado,** *that I shall have loved*
Conditional: **hubiera amado,** *that I should have loved.*

NOTE. Neither the table of inflexions in p. 2217 nor the above need be memorised at this stage. The somewhat extended treatment is given so that when the student reaches the reading stage, he may be able to return here for guidance. It is, all the same, advisable to read through these pages until the general principles are grasped. Once grasped, they are easily memorised.

Auxiliary Verbs

The two verbs **SER,** to be, and **HABER,** to have, are called auxiliaries, because they are used not only to express "to have" and "to be" but also to form compound tenses and the passive of all verbs. Hence, they are of great importance. They are both irregular. Note that **HABER** is the *auxiliary* verb for "*to have*"—*to possess* is **TENER.**

Infinitive: **SER,** *to be*
Present Participle: **siendo,** *being*
Past Participle: **sido,** *been*

Present Tense	*Imperfect Tense*
Yo soy, *I am*	**era,** *I was*
tú eres, *thou art*	**eras,** *thou wast*
él, ella es, *he, she is*	**era,** *he, she was*
nosotros, -as, somos, *we are*	**éramos,** *we were*
vosotros, -as, sois, *you are*	**erais,** *you were*
ellos, -as, son, *they are*	**eran,** *they were*

Past Definite	*Future*
fui *I was*	**seré,** *I shall be*
fuiste	**serás**
fué	**será**
fuimos	**seremos**
fuisteis	**seréis**
fueron	**serán**

Conditional	*Present Subjunctive*
sería, *I should be*	**(que yo) sea,** *(that) I be*
serías	**seas**
sería	**sea**
seríamos	**seamos**
seríais	**seáis**
serían	**sean**

Infinitive: **HABER,** *to have*
Present Participle: **habiendo,** *having*
Past Participle: **habido,** *had*

Present Tense	*Imperfect*
he, *I have*	**había,** *I had, used to*
has	**habías**
ha	**había**
hemos	**habíamos**
habéis	**habíais**
han	**habían**

Past Definite	*Future*
hube, *I had, did have*	**habré,** *I shall have*
hubiste	**habrás**
hubo.	**habrá**
hubimos	**habremos**
hubisteis	**habréis**
hubieron	**habrán**

Conditional	*Present Subjunctive*
habría, -ías, etc., *I should have*	**haya, -as, -a,** *that I have* **hayamos, -áis, -an**

Models for the Regular Conjugations

Infinitives **COMPRAR,** *to buy*; **VENDER,** *to sell*; **VIVIR,** *to live.* (Compare throughout with the Table on p. 2217.)

Pres. Participles **COMPRANDO,** *buying*; **VENDIENDO,** *selling*; **VIVIENDO,** *living*

Past Participles. **COMPRADO,** *bought*; **VENDIDO,** *sold*; **VIVIDO,** *lived*

Present Tense:

(1) **Compro, compras, compra, compramos, compráis, compran,** *I buy, thou buyest, he buys,* etc
(2) **Vendo, vendes, vende, vendemos, vendéis, venden**
(3) **Vivo, vives, vive, vivimos, vivís, viven**

Imperfect:

(1) **Compraba,** etc. *I was buying* (2) **Vendía,** etc. *I was selling* (3) **Vivía** *I was living*

Past Definite

(1) **Compré, compraste, compro, compramos, comprasteis, compraron.** (2) **Vendí,** etc. (3) **Viví** etc.

Future

(1)	**Compraré,**	**-ás,**	**-á,**	**-émos,**	**-eis,**	**-án**
(2)	**Venderé,**	,,	,,	,,	,,	,,
(3)	**Viviré,**	,,	,,	,,	,,	,,

Orthographic Changes

With the exception of the irregular verbs noted below, the tenses of all the verbs given in pp. 2237-39 can be formed in accordance with the rules stated. There are, however, certain simple orthographic changes which take place in the formation of parts of certain regular verbs, notably:

(1) Verbs ending in **-car** change the **c** into **qu** before an **e**. Thus: **tocar,** *to touch* **Yo toqué,** *I touched.*

(2) Similarly, verbs ending in **-gar** take **u** after **g** when an **e** follows. Thus: **pagar,** *to pay.* **Yo pagué,** *I paid* **Que él pague,** *let him pay.*

(3) Verbs ending in **-zar,** change **z** into **c** before **e**. Thus: **gozar,** *to enjoy.* **Yo gocé,** *I enjoyed*

(4) Verbs ending **-cer, -cir,** preceded by a consonant, change **c** to **z** before **a** or **o**. Thus: **vencer,** *to conquer* **Venzo,** *I conquer*

(5) But verbs ending in **-cer, -cir** preceded by a vowel take a **z** before the **c** when followed by **a** or **o**. Thus: **lucir,** *to shine* **Luzco,** *I shine*

(6) Verbs ending in **-ger, -gir** change **g** into **j** before **a** or **o**. Thus: **escoger,** *to select* **Escojo,** *I select.*

(7) Verbs ending in **-eer,** change the **i** of an ending into **y** when it occurs between two vowels and when unstressed Thus: **creer,** *to believe.* **Creyendo** (not **creiendo**), *believing*

(8) Verbs ending in **-guir, -quir,** drop the **u** before **a** or **o**. Thus **distinguir,** *to distinguish.* **Distingo,** *I distinguish*

NOTE. The above changes are, strictly speaking, not irregularities They are for the purpose of *preserving the sound of the stem as it is pronounced in the infinitive*, or for euphony, as in (5) above

The Passive of Verbs

The passive is formed by using the auxiliary **SER** with the past participle of the verb of which the passive is required. Thus:

Yo soy amado, él es amado, *I am loved, he is loved*

The participle agrees with the subject of the sentence. Thus:

Ella es amada, *She is loved.* **Ellos son amados, ellas son amadas,** *They are loved* (*masc.* and *fem.*).

When it is necessary to use a compound tense of the auxiliary **SER** before another past participle, then the past participle of **ser** remains invariable, while the past participle of the other (i.e. transitive) verb agrees in gender and number with its *subject* noun. Thus:

She has been loved, **Ella ha sido amada.** **Ellos han sido amados,** *They have been loved.*

The reflexive form (*see below*) is frequently used for the English passive:

Eso se hará pronto, *That will quickly be done.*

Reflexive Verbs

A verb is called reflexive (*a*) when its action is both performed and suffered by the subject, and (*b*) when two pronouns are used instead of one in conjugation. In English comparatively few verbs are reflexive, but there are many in Spanish, and they are not necessarily translated by the English reflexive. Thus: **lavarse,** *to wash oneself,* is a true reflexive verb in both languages, but **equivocarse** (*to make a mistake*) is reflexive in Spanish only.

Present Tense of **lavarse,** *to wash oneself*

Yo me lavo, *I wash myself*	**Nosotros** / **Nosotras** **nos lavamos**
Tú te lavas	
él / **ella** / **Vd.** **se lava**	**Vosotros** / **Vosotras** **os laváis**

Ellos, ellas, Vds. se lavan

And so on, throughout all other tenses.

In a compound tense, the order is (1) subject pronoun, (2) reflexive pronoun, (3) auxiliary, (4) past participle. Thus: **Yo me he lavado,** *I have washed myself.*

NOTE. Do not confuse the word **Mismo** (*same, self*) with the reflexive.

See page 2212 for use of **Mismo.**

The reflexive form is more often used as an equivalent of the English passive than the true passive form given earlier. But this chiefly applies to the third person, thus:

It is said that he is a doctor, **Se dice que es médico.** **No se explica cómo ha aprendido el castellano,** *It is not explained how he learnt Spanish.* **No se sabe la fecha,** *The date is not known* **Eso se comprenderá fácilmente,** *That will easily be understood.* **¿ Qué se debe hacer ?** *What is to be done ?* **Se habla inglés,** *English (is) spoken.* **¿ Se permite hacer eso ?** *May that be done ?* **Se necesita un mozo,** *A waiter is wanted.* **Se ruega a los Sres. pasajeros . . .** *Passengers are requested . . .* **¿ Cómo se llama Vd. ?** *What are you called ?* (*What is your name ?*). **Se habló de todo,** *Everything was discussed.* **Los diarios se venden en todos los kioskos,** *Newspapers are sold at all the kiosks.*

Negative of Verbs

To form the negative of any verb, put the word **NO** (*not*) before the verb or auxiliary:

Yo no compro, *I do not buy.* **No he comprado,** *I have not bought.*

The negative precedes all personal pronouns except the subject:

Yo no tengo dinero, *I have no money.* **No lo he conseguido,** *I have not obtained it.*

Other negatives are:

Nadie, *Nobody.* **Nada,** *nothing.* **Nunca,** *never* **No** (verb) **más que,** *not more than* . . **No tardo más tiempo que el necesario,** *I take only what time is necessary.* (Literally: "*I do not take more time than the necessary.*") **Nada más, nada menos,** *no more, no less.* **Ni . . . tampoco,** *Neither.* **Ni yo tampoco,** *Nor I either.* **No . . . ni,** *Not . . . nor.* **No compro el libro, ni tengo tiempo para leerlo,** *I do not (wish to) buy the book, nor have I time to read it.* **No tengo ni dinero ni géneros,** *I have neither money nor goods.* **No . . . ni siquiera . . .,** *Not . . . even.* **No le conozco ni siquiera de vista,** *I do not know him even by sight.* **No . . .nadie no . . . ninguno,** **No he visto a nadie,** *I have not seen anybody.* **No hay ninguna casa,** *There is no house.*

TABLE OF INFLEXIONS OF REGULAR VERBS

(This table is for reference only)

Infinitives	1st conjugation :	**-AR (comprar)**
	2nd conjugation :	**-ER (vender)**
	3rd conjugation :	**-IR (vivir)**

Present Participles	1. **-ando** 2. **-iendo** 3. **-iendo**	*Past Participles*	1. **-ado** 2 **-ido** 3. **-ido**

Indicative

Present Tense	1.	**-o, -as, -a ; -amos, -áis, -an**
	2.	**-o, -es, -e ; -emos, -éis, -en**
	3.	**-o, -es, -e ; -imos, -is, -en**
Imperfect	1.	**-aba, -abas, -aba , -ábamos, -abais, -aban**
	2 and 3.	**-ía, -ías, -ía ; -íamos, -íais, -ían**
Past Definite	1.	**-é, -aste, -ó ; -amos, -asteis, -aron**
	2 and 3.	**-í, -iste, -ió ; -imos, -isteis, -ieron**
Future, all conjugations :		**-é, -ás, -á ; -emos, -éis, án**
Conditional, all conjugations :		**-ía, -ías, -ía ; -íamos, -íais, -ían**

Imperative

1. **-a, -e ; -emos, -ad, -en**
2. **-e, -a ; -amos, -ed, -an**
3. **-e, -a ; -amos, -id, -an**

Subjunctive

Present Subj.	1.	**-e, -es, -e ; -emos, -éis, -en**
	2 and 3.	**-a, -as, -a ; -amos, -áis, -an**
Imp. Subj.		**-ara, -aras, -ara ; -áramos, -arais, -aran**
		-ase, -ases, -ase ; -ásemos, -aseis, -asen
	2 and 3	**-iera, -ieras, -iera ; -iéramos, -ierais, -ieran**
		-iese, -ieses, -iese ; -iésemos, -ieseis, -iesen
Future Subj.	1	**-are, -ares, -are ; -áremos, -areis, -aren**
	2 and 3.	**-iere, -ieres, -iere ; -iéremos, -iereis, -ieren**

The negative imperative follows the same rules as the simple negative :

No haga eso, *Do not do that.* **No toque esto,** *Do not touch this.*

Juan, no abras aquella puerta, por favor ; *John, please do not open that door.*

No me diga Vd. eso, *Don't tell me that*

To Use the Verb Interrogatively

Place the subject pronoun or noun after the verb to ask a question. Thus :

¿ Tengo yo ? *Have I ?* **¿ Tiene Vd. ?** *Have you ?* **¿ Es bueno el muchacho ?** *Is the boy good ?*

In Spanish it is very common to ask a question merely by modulating the voice, and without changing the construction of a direct statement. Thus :

¿ El padre va a venir ? *Will the father come ?*

The inverted note of interrogation or exclamation (¿ ¡) is placed at the beginning of a Spanish sentence to inform the reader in advance of the necessity for modulation. **¡ Bueno !** *Good !*

Impersonal Verbs

The verb **Haber** is used impersonally for "*there . . . to be.*" *There is, there are,* is expressed by an irregular form **Hay.** Other useful forms are : **había,** *there was,* **Hubo,** *there was* (definite or historical past). **Habrá,** *there will be.* **Habría,** *there would be.*

NOTE ALSO. **Amanece,** *day is breaking.* **Anochece,** *night falls.* **Hiela,** *it is freezing.* **Llueve,** *it is raining.* **Relampaguea,** *it is lightning.* **Truena,** *it is thundering.* **Ventea,** *the wind blows.* **Basta,** *it is sufficient.* **Parece,** *it seems.* **Importa,** *it matters.* **Conviene,** *it suits.* **Es de esperar,** *it is to be hoped.* **Es lástima,** *it is a pity.* **Es necesario,** *it is necessary.* **Está claro,** *it is clear.*

EXERCISE ON PRONOUNS AND VERBS

The student should now have sufficient vocabulary to enable him to work out the meaning of the following sentences. He should, wherever necessary, turn to Lessons 9 and 10 for the meaning of words not known.

¿ Quién *le* habla a Vd. ?

***Me* habla mi vecino.**

¿ Qué *le* dice a Vd. ?

***Me* dice que consulte a mi abogado.**

¿ *Le* consultará Vd. ?

Si *le* consultaré.

¿ *Le* costará a Vd. mucho la consulta ? Probablemente *me* costará más de lo que puedo pagar*le*.

Este *lo* dijo, ése *lo* oyó, y aquél *lo* repitió por todas partes (*through all parts—everywhere*). **Vds. no *lo* creen pero yo afirmo que esto es verdad. *Lo* afirmé entonces y *lo* afirmaré siempre.**

Mi amigo *me* consultaba y yo *le* consultaba a él. Siempre *nos* consultábamos el uno al otro. Un día *le* pedí consejo acerca de la compra de cierto automóvil. " No *lo* compre Vd " —*me* dijo—. Yo *lo* examiné ayer y no funcionaba (*worked*) **bien. *Me* recomendó** (*recommended*) **otro que, aunque más caro, era mejor. Fuimos a ver*lo*, *lo* inspeccionamos** (*inspected*) **y, finalmente, *lo* compré.**

—**¡ Oye, niño !** (*Hallo, youngster !*)

—**¿ *Me* llama Vd. ?**

—**Si, *te* llamo.**

—**¿ Qué desea Vd., señor ?**

—**¿ Puedes decir*me* dónde está la calle de . . . ? Soy extranjero y *me* he perdido.**

Si señor, con mucho gusto. Siga Vd. por esta calle hasta que llegue a una gran plaza con árboles ; crúce*la* Vd y siga un poco más. *La* segunda bocacalle (*turning*) **a la derecha es *la* que Vd. busca.**

—**Muchas gracias. Ahora estoy seguro de que *la* encontraré. ¿ Cómo *te* llamas ?**

—***Me* llamo Antonio. *Mi* padre *se* llama también Antonio ; y Vd. ¿ Cómo *se* llama ?**

Yo *me* llamo Jaime. ¿ *Te* gustan los dulces ?

—**Sí, mucho.**

—**Pues toma este dinero y cómprate algunos.**

Mil gracias señor.

—**Adiós Antonio.**

—**Vaya Vd. con dios, Don Jaime.**

¿ Estudia Vd. el Español ?

—***Lo* estudio.**

—**¿ *Lo* ha estudiado Vd. antes ?**

Sí, *lo* he estudiado.

—**¿ Cuando *lo* estudió Vd. ?**

—***Lo* estudié cuando era joven.**

—**¿ Aprendió Vd. mucho ?**

—**No aprendí mucho.**

—**¿ Quién *le* enseñaba a Vd. ?**

—**Me enseñaba un maestro viejo.**

—**¿ Quién *se lo* enseña a Vd. ahora ?**

—**Me lo enseña un maestro joven.**

—**¿ Aprende Vd. a pronunciar *lo*** (*to pronounce*) **bien ?**

—**Sí, como mi maestro es joven *lo* pronuncia bien ; *lo* pronuncia claramente y despacio.**

—¿ Dónde *lo* aprende Vd. ?

—*Lo* aprendo en la escuela.

—¿ *Le* enseña el maestro a Vd. sólo ?

—No, él *lo* enseña a varios alumnos de la escuela. *Nos lo* enseña a todos a la vez. *Nos* explica las reglas de la gramática ; si no *las* comprendemos, *las* repite una y otra vez hasta que *las* sabemos bien. *Nos* pone muchos ejemplos. *Nos* lee en alta voz, *nos* dicta una anécdota y luego *nos* corrige el dictado. *Nos* hace preguntas y nosotros *le* contestamos. Cuando explica, lee y dicta, *le* escuchamos con atención. Si hacemos errores, *nos los* corrige.

—¿ *Les* gusta a Vds. el español ?

—Sí, *nos* gusta. Hemos estado estudiándo*lo* seis meses. Ahora podemos leer*lo*, comprender*lo* y escribir*lo* bastante bien.

—¿ *Lo* estudiará Vd. cuando acabe el curso ?

—Sí, seguiré estudiándo*lo* (*I will go on studying it*) **por mi mismo.**

—¿ Cree Vd. que podrá aprender*lo* bien en un año ?

—Creo que sí.

LESSON 6

Irregular Verbs and Verbal Usages

The student should now have a good idea of the working of *regular* verbs ; this lesson introduces the irregularities. Apart from **Ser** and **Estar,** it should be treated as chiefly for reference at this stage. But sooner or later it must be known. Take it easy now. Read it all through a few times until the general principles are known. On a second perusal of the Course, settle down to *master* it—there is none of it which can be omitted entirely if the student wishes to read Spanish with ease.

As has been seen, there are two verbs in Spanish for the English "to be." **Ser** has already been conjugated as an auxiliary. **Estar** will be found among the irregular verbs following. There is a fundamental difference between the meaning of **ser** and **estar,** the usage of which often puzzles foreigners. And yet, apart from subtleties in style (with which the foreigner need seldom be concerned unless he attempts to translate literature), this difference can be tabulated :

SER	ESTAR
(1) Represents permanency or the essential : **Yo soy pálido,** *I am by nature pale.*	Represents the temporary or accidental : **Yo estoy pálido,** *I am pale—just at this moment.*
(2) Expresses origin, nationality, ownership, or material. **Yo soy de Londres. Yo soy Inglés. El perro es de mi hermano. La mesa es de madera.** *I am from London. I am an Englishman. The dog is my brother's The table is of wood.*	Expresses location : **Madrid está en España y mi hermano está ahí,** *Madrid is in Spain and my brother is there.*
(3) A profession, or a calling. **Yo soy cónsul,** *I am a consul.*	But not if it is transitory. **Estoy ahora de cónsul aquí,** *I am (acting as) consul here.*
(4) With **bueno** and **malo,** refers to character : **Mi padre es bueno,** *My father is a good man.*	With **bueno** and **malo,** refers to health : **Mi padre está malo,** *My father is ill, a sick man.*
(5) Is the true auxiliary : **Yo soy amado,** *I am loved.* *N.B.—All passives are formed with it.*	Follows generally the meaning of the original Latin word "*stare*" to stand, from which it is derived. Hence we say, **Estoy hablando,** *I am speaking.* *N.B.—The continuous present is always formed with it.*
(6) Is used to translate the impersonal "*it*" : *It is late, early,* **Es tarde, temprano.** And in the phrase **¿ No es verdad ?** *Is it not so ?* (*N'est-ce pas ?*) Also for time : **Es la una, son las dos**	But we say : **Está claro,** *It is clear.*

The above are fairly safe rules and cover most cases. But they are by no means exhaustive or impregnable. The correct use of **ser** and **estar** is undoubtedly difficult to master ; having memorised the above rules, the student should for a long time look closely at the usage of **ser** and **estar** whenever he meets these words in reading. He will learn to distinguish between "**Soy borracho**" and "**estoy borracho**" and to realize that the latter is less serious than the former. So, for some time, beware of **ser** and **estar** !

The Subjunctive and Its Uses
(For Reference)

The correct use of the Subjunctive is one of the difficulties of Spanish. There is a tendency in all the Latin languages for this mood to fall into disuse, and this fact may be a solace to the English student. If he wishes to become an accurate translator he will have to study very carefully the rules given in one of the bigger grammars, or appeal for guidance to the final arbiter in all such matters—the Grammar of the Academy. Unfortunately for the English student, it is not possible to avoid the Subjunctive in Spanish—it is in everyday use.

General Indications.—After DESIRE, UNCERTAINTY, EMOTION, INDIRECT STATEMENT, or

INDIRECT QUESTION the Subjunctive Mood is usually employed. Also after relative pronouns and certain conjunctions.

1. DESIRE (including command, request, suggestion, permission, approval, and disapproval) :

Le ruego a Vd. que se vaya, *I beg you to go away.*

¡ Viva el rey, la república ! *Long live the King, the Republic !*

2. UNCERTAINTY, EMOTION (includes entreaty, surprise, fear, denial) :

Temo que se lo diga a él, *I fear that (lest) he may tell it to him.*

Extraño mucho que Vd. no lo haya hecho, *I am greatly surprised that you have not done it*

3. INDIRECT STATEMENTS OR QUESTIONS :

Dijo que ellos hablaran (or hablasen) en la tienda, *He said that they should converse in the shop.*

¿ Cree Vd. que mi hermano se alegre mucho de eso ? *Do you believe that my brother is very delighted about that ?*

It will be noticed that in the Table of Inflexions two forms for the imperfect subjunctive are given. The first (**-ara, -iera**) is used as a conditional subjunctive, corresponding approximately to the English, That I should. Thus : **Que yo amara,** *That I should love.* The second (**-ase, -iese**) is the imperfect subjunctive proper : **Que yo amase,** *That I loved.*

4. AFTER A RELATIVE :

Quiero un amigo que hable castellano, *I wish to have* (or, *I want*) *a friend who speaks Spanish.*

Si Vd. quiere un libro español cuyo estilo sea bueno, yo se lo prestaré, *If you require a Spanish book of which the style is good, I will lend you one*

The Subjunctive is also used after compounds of **QUIERA,** *-ever* (**Quienquiera,** *whoever* ; **dondequiera,** *wherever* ; **cuandoquiera,** *whenever* ; **comoquiera,** *however* ; **cualquiera,** *whatever, whichever*)

Quienquiera que sea, *Whoever he may be,* etc.

5. AFTER CERTAIN CONJUNCTIONS, etc :

For List *see* p 2241

En caso que	**llegue.**	*In case he arrives.*
No obstante que	**llegue.**	*Notwithstanding his arrival.*
Aunque	**llegue.**	*Although he arrives.*

The Subjunctive is also used after Impersonal Verbs (*see* p 2217).

Es menester que venga, *It is necessary for him to come.*

How to Translate "If"

The translation of this word into Spanish needs care. The present indicative can be used for most cases : **Si tengo tiempo le escribiré,** *If I have time, I shall write to you.* For a straightforward conditional "if," etc., use the Spanish imperfect subjunctive : **Si él tuviese tiempo, sin duda habría escrito,** *If he had time, no doubt he would have written.*

But if there is very much doubt whether the action can be done, then the future subjunctive should be used : **Escribiré si pudiere,** *I shall write if I can* (*though I'm very doubtful indeed if I shall be able*—all this is understood). One could also say : **Escribiré si tuviera tiempo.** When *if* is equivalent to *whether* use the conditional indicative in Spanish : **No sabia si él podría venir,** *I did not know if* (*whether*) *he would be able to come.*

Irregular Verbs

1. First Conjugation Verbs in -AR. The most important groups of verbs in this conjugation are very slightly irregular. They merely change the **-e-** of the stem into **-ie-** when the stress is moved from the last syllable (in the infinitive) to the one before it with the various inflexions. For example, take the verb **Cerrar,** to shut. This becomes **cierro** in the present indicative first person, the **-ie-** syllable being the one stressed. But the first person plural is **cerramos,** because the accent in this word is on the **-a-** and not on the **-e-**. The full conjugation of the present indicative is :

Cierro, cierras, cierra, cerramos, cerráis, cierran. And the present subjunctive : **cierre, cierres, cierre, cerremos, cerréis, cierren.** The imperative is : **Cierre (Vd.),** *shut.* **Que él cierre,** *let him shut* **Cerremos,** *let us shut.* **Cierren (Vds.),** *shut* (polite plural). The rest of the verb is regular.

Thus **Cerré,** *I shut* (past definite). **Cerraba,** *I was shutting.* **Cerraré,** *I shall shut.*

Essential Verbs like **cerrar** are :

Calentar, *to warm*	**Negar,** *to deny*
Comenzar, *to begin*	**Nevar,** *to snow*
Confesar, *to confess*	**Pensar,** *to think*
Despertar, *to awake*	**Plegar,** *to fold*
Empezar, *to begin*	**Quebrar,** *to break*
Gobernar, *to govern*	**Recomendar,** *to recommend*
Helar, *to freeze*	**Sentarse,** *to seat oneself*
Manifestar, *to manifest*	

Similarly there is another group in which the **-o-** of the stem changes to **-ue-** with the change of stress. **Costar,** *to cost.*

Present Indicative : **Cuesto, cuestas, cuesta, costamos, costais, cuestan.** And the Present Subjunctive : **Cueste, cuestes, cueste, costemos, costéis, cuesten.**

Essential verbs conjugated like **costar** are :

Acordar, *to agree*	**Probar,** *to prove*
Acostarse, *to lie down (go to bed)*	**Recordar,** *to remind*
	Recordarse, *to remember*
Almorzar, *to breakfast*	**Renovar,** *to renew*
Colgar, *to hang*	**Rogar,** *to pray, beg*
Concordar, *to agree*	**Sonar,** *to sound*
Consolar, *to comfort*	**Soñar,** *to dream*
Contar, *to count, relate*	**Tronar,** *to thunder*
Encontrar, *to meet*	**Volar,** *to fly*
Forzar, *to force*	

Compounds of these are similarly conjugated.

JUGAR, *to play,* changes the **-u-** into **-ue-** in a similar manner **Juego, juegas, juega, jugamos, jugáis, juegan.** And so on.

ANDAR, *to walk,* has an irregular Past Definite : **Anduve, anduviste, anduvo, anduvimos, anduvisteis, anduvieron.** Excepting the little used Imperfect, Future, and Conditional of the Subjunctive, it is otherwise regular. Thus **Ando,** *I go.* **Andaré,** *I shall go,* etc

DAR, *to give.* This important verb is conjugated as follows :

Pres Ind. : **Doy, das, da, damos, dais, dan.**

Past Def : **Dí, diste, dió, dimos, disteis, dieron.**

Otherwise it is regular : **Daré,** *I shall give.* **Dado,** *given,* etc.

ESTAR, *to be,* in a temporary sense (see p. 2218) : **estando, estado.**

Pres. Ind. : **Estoy, estás, está, estamos, estáis, están.**

Past Def. : **Estuve, estuviste, estuvo, estuvimos, estuvisteis, estuvieron.**

Pres. Sub. : **Esté, estés, esté, estémos, estéis, estén.** Otherwise regular.

2. Second Conjugation Verbs in -ER. The most important group of verbs in this conjugation ending in **-acer, -ecer, -ocer** (excepting **hacer,** *to do,* and **cocer,** *to cook*) are conjugated like **Conocer,** *to know* :

Pres. Ind. : **Conozco, conoces, conoce, conocemos, conocéis, conocen.**

Pres. Subj. : **Conozca, conozcas, conozca, conozcamos, conozcáis, conozcan.** They are otherwise regular : **Conocí,** *I knew.* **Conoceré,** etc.

The verb **Lucir,** *to shine,* of the third conjugation, is conjugated similarly. **Luzco,** *I shine.* **Luces, luce,** etc. Pres. Subj . **Luzca,** etc.

HACER, *to make* or *do,* is as follows : Pres. Part **haciendo,** *doing.* Past Part. : **HECHO,** *done.*

Pres. Ind. . **HAGO,** *I do.* **Haces, hace, hacemos, haceis, hacen.**

Pres Subj. . **Haga, hagas, haga, hagamos, hagais, hagan.**

Imperative **Haga (Vd.),** *pl.* **Hagan (Haz tú,** *do thou*).

Past Def. : **Hice, hiciste, hizo, hicimos, hicisteis, hicieron.**

Future **Haré, -ás, -á, -emos, -éis, -án.**

Compounds of **Hacer** are similarly conjugated . **Deshacer,** *to undo.* **Rehacer,** *to redo, do again* ; and **satisfacer,** *to satisfy* **(satisfecho,** *satisfied,* the most common part).

ENTENDER, *to understand.* Pres Ind. : **Entiendo, entiendes, entiende, entendemos, entendéis, entienden.** Pres. Sub **Entienda,** etc.

Like **Entender** are : **Defender,** *to defend.* **Perder,** *to lose.* **Pierdo, pierdes, pierde,** etc.

TENER, *to have, hold, possess,* always translates English " to have " except when used as an auxiliary. **Teniendo, tenido.**

Pres. Ind **Tengo, tienes, tiene, tenemos, tenéis tienen.**

Past Def. **Tuve, tuviste, tuvo, tuvimos, tuvisteis, tuvieron.**

Future . **Tendré, -ás, -á, -emos, -éis, -án.**

Pres Sub. : **Tenga, -as, -a, -amos, -áis, -an.**

Imperative **ten, tenga (Vd.), tened, tengan (Vds.).**

There is a group of **-ER** verbs conjugated similarly to **costar** (*see* p. 2219). For example :

Absolver, *to absolve.* **Absuelvo,** *I absolve.*

Pres. Subj. . **Absuelva,** etc. Imperative . **Absuelva, absuelvan (Vd.** and **Vds.).** Such are :

Cocer, *to cook*	**Oler,** *to smell*
Doler, *to ache*	**Resolver,** *to resolve*
Llover, *to rain*	**Soler,** *to be accustomed*
Morder, *to bite*	**Torcer,** *to twist*
Mover, *to move*	**Volver,** *to return*

And all the compounds of these verbs

CAER, *to fall.* **Caigo,** *I fall.* Otherwise regular : **caes, cae,** etc. And its compounds: **Decaer,** *to decay.* **Recaer,** *to fall again*

PODER, *to be able.* **Pudiendo,** *being able.* **Podido,** past part.

Pres. Ind.: **Puedo, puedes, puede, podemos, podéis, pueden.**

Past Def. : **Pude,** etc. Future **Podré,** etc.

PONER, *to put.* Past Part.: **puesto,** *put.* Past Def.: **Puse.** Pres. Ind. : **Pongo, pones, pone, ponemos, ponéis, ponen.**

QUERER, *to wish, like.* Pres. Ind. : **Quiero, quieres, quiere, queremos, queréis, quieren.**

Past Def. : **Quise, quisiste, quiso, quisimos, quisisteis, quisieron.**

Future : **Querré,** etc. Pres Subj. : **Quiera.** etc. Conditional : **Querria,** etc.

SABER, *to know.* **Sabiendo,** *knowing.* **Sabido.** *known.* Pres. Ind.: **Sé, sabes, sabe, sabemos, sabéis, saben.** Future: **Sabré,** etc. Past Def.: **Supe, supiste, supo, supimos, supisteis, supieron.** Pres. Subj.. **Sepa,** etc.

TRAER, *to bring, carry.* Past Part.: **Traido.** Pres. Ind. : **Traigo,** *I carry* ; **traes, trae, traemos, traéis, traen.** Past Def. . **Traje, trajiste, trajo, trajimos, trajisteis, trajeron.** Future : **Traeré,** etc. Similarly. the compounds : **Atraer,** *to attract.* **Contraer,** *to contract.* **Distraer,** *to distract.*

VALER, *to be worth.* Pres. Ind.: **Valgo, vales, vale, valemos, valéis, valen.** Pres. Subj. : **Valga, etc.** Past Def. : **Valí.** Future : **Valdré.** Conditional : **Valdria.** Similarly . **Equivaler,** *to be of equal value,* and **prevaler,** *to prevail.* Also the **-ir** verb **salir,** *to go out of* ; **Salgo, sales, sale,** etc. Future: **Saldré,** etc., *see* below.

VER, *to see.* Past Part. : **Visto,** *seen.* Present : **Veo, ves, ve, vemos, veis, ven.** Imperfect : **Veia.** Pres. Subj. : **Vea,** etc. Past Def : **Vi, viste, vió, vimos, visteis, vieron.** Future : **Veré,** etc. Compounds : **Prever,** *to foresee.* **Rever,** *to review.*

3. Third Conjugation Verbs in -IR. There is a group of verbs ending **-ucir,** similar to the **-cer** verbs in **-ER. Conducir,** *to conduct, lead*; **conduciendo, conducido.**

Pres. Ind.: **Conduzco, conduces, conduce, conducimos, conducís, conducen.**

Past Def **Conduje, condujiste, condujo, condujimos, condujisteis, condujeron.**

Future **Conduciré,** etc.

Pres Subj. : **Conduzca, -uzcas, -uzca, -uzcamos, -uzcáis, -uzcan.**

Similar to **conducir** are : **Deducir,** *to deduct, infer* **Producir,** *produce* **Reducir,** *reduce.* **Traducir,** *translate.* And **Lucir,** *shine* (*see* above).

SENTIR, *to feel, to be sorry.* **Sintiendo, sentido.**

Pres Ind . **Siento, sientes, siente, sentimos, sentís, sienten.**

Past Def. . **Sentí, -iste, sintió, sentimos, sentisteis, sintieron.**

Future : **Sentiré, -ás, -á,** etc.

Pres. Subj . **Sienta, -as,** etc.

Verbs conjugated like **sentir** are **Advertir,** *to warn* **Convertir,** *to convert.* **Mentir,** *to lie* **Preferir,** *to prefer* And their compounds

DORMIR, *to sleep.* **Durmiendo, dormido.**

Pres. Ind. : **Duermo, duermes, duerme, dormimos, dormis, duermen.**

Past Def. : **Dormí, dormiste, durmió, dormimos, dormisteis, durmieron.**

Future : **Dormiré,** etc. Pres. Subj.. **Duerma, -as,** etc **Durmamos, durmáis, duerman.**

MORIR, *to die* **Muriendo.** Past Part. **Muerto**

Pres. Ind. : **Muero, mueres, muere, morimos, moris, mueren.**

Past Def. : **Morí,** etc , like **dormí.**

PEDIR, *to ask.* **Pidiendo, pedido.**

Pres. Ind. : **Pido, pides, pide, pedimos, pedis, piden.**

Past Def.: **Pedi, pediste, pidió, pedimos, pedisteis, pidieron.**

Future : **Pediré,** etc. Pres. Subj. : **Pida, pidas,** etc

And its compounds : **Despedir,** *dismiss.* **Impedir,** *prevent.* Also : **Reir,** *to laugh.* **Seguir,** *to follow* **Servir,** *to serve.* **Vestir,** *to clothe.* And compounds of these verbs.

VENIR, *to come.* **Viniendo, venido.**

Pres. Ind. : **Vengo, vienes, viene, venimos, venis, vienen.**

Past Def.: **Vine, viniste, vino, vinimos, vinisteis, vinieron.**
Future: **Vendré, -ás, -á,** etc. Pres. Subj.: **Venga, vengas,** etc.
And its compounds: **Contravenir,** *contravene.* **Intervenir,** *to intervene,* etc. **Convenir,** *to agree.*

DECIR, *to say, tell.* **Diciendo, dicho.**
Pres. Ind.: **Digo, dices, dice, decimos, decís, dicen.**
Past Def.: **Dije, dijiste, dijo, dijimos, dijisteis, dijeron.**
Future: **Diré,** etc. Pres. Subj.: **Diga, digas, diga,** etc.
Also: **Bendecir,** *to bless.* **Maldecir,** *to curse*, but these have regular Futures.

OÍR, *to hear.* **Oyendo, oído.**
Pres. Ind.: **Oigo, oyes, oye, oímos, oís, oyen.**
Past Def.: **Oí, oíste, oyó, oímos, oísteis, oyeron.**
Future: **Oiré,** etc. Pres. Subj.: **Oiga, oigas,** etc.

SALIR, *to go out, set out, leave* **Saliendo, salido.**
Pres. Ind.: **Salgo, sales, sale, salimos, salís, salen.**
Past Def.: **Salí, saliste, salió, salimos, salisteis, salieron.**
Future: **Saldré, -ás, -á,** etc. Pres. Subj.: **Salga, salgas,** etc.

IR, *to go.* **Yendo, ido.**
Pres. Ind.: **Voy, vas, va, vamos, vais, van.**
Past Def.: **Fui, fuiste, fué, fuimos, fuisteis, fueron.**
Future: **Iré, -ás, -á, -emos, -éis, -án.**
Imperfect: **Iba, ibas, iba, íbamos, íbais, iban.**
Pres. Subj: **Vaya, vayas, vaya, vayamos, vayáis, vayan.**
Imperative: **Ve, vaya (Vd.), vamos, id, vayan.**

NOTE. Under the **-AR** verbs will be found **ANDAR,** *to go, to walk.* The difference between the use of **andar** and **ir** is that the former has in it an indication of undefined movement —that of animals, clocks, machines and inanimate objects generally. **IR** means a definite movement in a specific direction. Thus:

Mi reloj no anda bien, *My watch does not go well.* **Este caballo anda despacio,** *This horse goes slowly.* But: **Voy a casa,** *I am going home (to the house).*

The imperative **¡Vamos!** is a common interjection which means: "*Let us come!*" (or *go*); also used to express surprise, disbelief, and sometimes even contempt. After hearing a tall story, one may say: **¡Vamos!**

4. Irregular Past Participles

Abrir, *to open*; **ABIERTO,** *opened*
Cubrir, *to cover*; **CUBIERTO**
Escribir, *to write*; **ESCRITO**
Imprimir, *to print*; **IMPRESO.** (**Impresos,** *printed matter*)
Volver, *to turn*; **VUELTO**
Concluir,* *to conclude*; **CONCLUSO**
Incluir,* *to include*; **INCLUSO**
Juntar,* *to join*; **JUNTO**
Romper, *to break*; **ROTO**
Torcer,* *to twist*; **TORCIDO** or **TUERTO**
Freír,* *to fry*; **FRITO**
Decir, *to say, tell*; **DICHO**

* These verbs have also regular past participles in common use.

CONOCER, SABER, and PODER

SABER is used for knowledge or understanding of a fact or subject, and demands intellectual ability. **¿Sabe Vd. francés?** *Do you know French?*

CONOCER is used for acquaintanceship or superficial knowledge. **¿Conoce Vd. al Francés?** *Do you know the Frenchman?*

PODER is used for purely *physical* ability. Thus: **Yo no sé leer,** *I do not know how to read.* **Yo no puedo leer,** *I cannot read (because I am blind).* **Yo no conozco ese camino,** *I do not know that road (because I have never travelled it).*

Some Idiomatic Usages of Verbs

¿Qué quiere decir eso? *What does that mean?* **Yo siento el frío,** *I feel the cold.* **Siento mucho que . . .** *I am very sorry that . . .* **Yo estoy de pie,** *I am standing up.* **Ponerse en pie,** *to stand up (the action).* **Ir a pie,** *to walk (on foot).* **Ir en automóvil,** *to go by car.* **Vale más hacer eso,** *It is better to do that.*

Oír means to hear any noise. **Entender** means to hear with intelligence or understanding. **Yo entiendo el castellano,** *I understand Spanish.*

Hacer is used before other verbs in the sense of *to cause* or *to make.* **Hacer saber,** *to make known.* (Note that the infinitive is used after it.) **Hacer falta** means *to be short of.* **Le hace falta a Vd.,** *You are short of.*

Two verbs **DAR** and **ECHAR** (*to throw*) form many idioms. **Dar un paseo, una vuelta,** *to take a walk.* **Dar voces,** *to shout.* **Dar guerra,** *to wage war.* **Dar una carcajada,** *to burst into laughter (explode).*

ECHAR is a dreadful verb (look at the dictionary and you will realize what is meant). The simple meaning is *to throw,* but it can mean all sorts of things. Remember the following: **Echar carnes,** *to grow fat.* **Echar las cartas,** *to deal the cards.* **Echar llave a la puerta,** *to lock the door.* **No me echarán de menos cuando muera,** *They will not miss me when I die.* **Echo de ver que Vd. está cansado,** *I notice that you are tired.* **Me eché a llorar,** *I burst into tears (I began to weep).* **Lo echará a perder,** *He will spoil it.*

The verb **doler,** *to pain, ache,* is used as follows: **Me duele la cabeza, la mano,** *My head, hand, aches.* **Me duelen los pies,** *My feet ache.*

Dejar means *to leave, allow, permit.* **Déjale solo,** *leave him alone (by himself).* **Dejar de** means *to cease from,* or *to fail to.* **No dejaré de escribir,** *I shall not fail to write.* **Deje Vd. de hablar,** *Stop talking.*

Deber before another verb expresses a duty. **Debo venir,** *I must come.*

Tener que is even stronger. **Tengo que venir,** *I must come.*

The Preposition "A" after a Verb

The preposition **a** (*to*) is used in Spanish in most cases where it would be used in English. It is also often used where no preposition would be used in English, and as this usage is extremely common in Spanish it must be mastered.

RULE. Where the *direct* object of an *active* verb is a person or persons, the preposition **a** must precede such a direct object.

Thus: **No conozco a Fernández,** *I do not know Fernandez.* **No comprendo a mi amigo,** *I do not understand my friend.* **Yo he llamado al padre,** *I have called the father.* **Mi amigo quiso ver a sus hijos,** *My friend wished to see his sons.*

Two important inferences from the above rule are (1) that **a** is required before proper names of persons in all circumstances, and (2) before demonstrative, interrogative, relative, and indefinite pronouns when they represent the object.

No hallo a ninguno, *I do not find anybody.* **No he visto a nadie,** *I have not seen anybody.*

Sometimes **a** is used when the direct object is not a person but some *familiar* or intelligent animal: **He visto al gato en la habitación,** *I saw the cat in the room.*

The two verbs **Querer** and **Tener** are exceptions to the above rules and do not take **a** before their direct objects, unless used in their specialized meanings of *to hold* and *to love*. Thus:

Tengo un amigo, *I have a friend.* **Tengo una hermana,** *I have a sister.* But . **Tengo al caballo,** *I am holding the horse.* **Tengo a mi amigo,** *I am holding my friend* (or *relying on him*). **Quiero una camarera,** *I want a waitress, stewardess.* **Quiero a una camarera,** *I like (love) a waitress*

It will be seen from the last example that one must be careful to use **a** correctly with **querer** or embarrassing misunderstandings may arise.

Prepositions and the Infinitive

(1) The preposition **PARA** (*for*) followed by an infinitive indicates purpose, "*in order to*": **Necesito una pluma para escribir,** *I require a pen to write.*

(2) Generally the English "*to*" before an infinitive is translated by **DE**: **No tengo tiempo de hacer esto,** *I have not time to do this.*

(3) But a few common verbs when followed by other verbs take the preposition **a**. These are:

Empezar, *to begin.* **Invitar, convidar,** *to invite.* **Enseñar,** *to teach.* **Aprender,** *to learn.* **Persuadir,** *to persuade.* Thus **Empiezo a hablar,** *I begin to speak.* **El me ha enseñado a hablar inglés,** *He has taught me to speak English*

(4) As a rule verbs of motion take the preposition **a**. **Andar, salir, venir, volver,** and the regular verb **correr,** *to run.*

(5) No preposition is required after verbs used impersonally.

(6) There is a list of verbs which do not take any preposition when followed by another infinitive. They are as follows:

acostumbrar, *to accustom*	**parecer,** *to seem*
agradar, *to gratify*	**pensar,** *to think*
bastar, *to suffice*	**permitir,** *to permit*
deber, *to owe (duty)*	**poder,** *to be able*
dejar, *to allow*	**preferir,** *to prefer*
desear, *to want*	**prometer,** *to promise*
esperar, *to hope*	**saber,** *to know*
gustar, *to like*	**sentir,** *to feel*
hacer, *to make*	**ser lástima,** *to be a pity*
importar, *to matter*	**servirse,** *to be pleased*
intentar, *to intend*	**soler,** *to be wont to*
mandar, *to order*	**temer,** *to fear*
necesitar, *to want*	**valer más,** *to be better*
ofrecer, *to offer*	**ver,** *to see*
oir, *to hear*	

Examples

Sírvase cerrar la puerta, *Please shut the door.* **Es lástima hacer eso,** *It is a pity to do that.* **Prefiero irme,** *I prefer to go (out of this).* **Debo escribir una carta,** *I must write a letter.* **No puedo comprender una palabra,** *I cannot understand a word.* **Deseo hablarles,** *I wish to speak to them.*

NOTE. The above list of verbs must sooner or later be memorised. With it and the preceding five general rules the student will seldom be at a loss to use the Spanish verbs fairly correctly in so far as using them with a preposition is concerned. This is one of the common difficulties of Spanish, the full scope of which will be appreciated in reading; and mastered only by continual attention. Outside the few rules given one can only say: Follow the usage of the best authors and speakers.

A list of essential verbs will be found in pp. 2237-39.

GENERAL RECAPITULATORY EXERCISE

On a first perusal of the Course all the reader need do with this exercise is first work out the meaning (a translation is given of difficult parts) and then read the whole over once or twice in order that a *general idea of principles* may enter the memory. On a second perusal, concentrate, so that the principles may be so thoroughly mastered that they will remain in the memory. It is best not to attempt to assimilate too quickly all of the previous lesson and all that is in this exercise too quickly. At this stage, follow the motto "Hasten slowly"!

On the Passive Voice

Los tiranos (*tyrants*) *son* **temid***os* **pero no son amad***os*.

El Palacio de Cristal *ha sido* **destru***ido* **por un incendio** (*fire*) **terrible.**

La ciudad de Barcelona *fué* **fund***ada* **por el General Cartaginés** (*Carthaginian*) **Amilcar Barca.**

Los Ministros *han sido* **consult***ados* **por el Rey acerca de la crisis europea.**

Italia *fué* **conden***ada* **por la Sociedad de Naciones.**

Méjico *fué* **conquist***ado* **por Hernán Cortés. Su fuerza consistía en unos seiscientos hombres a bordo** (*on board*) **de once naves** (*vessels*). **Con esta pequeña fuerza** *fueron* **venc***idos* **muchísimos indios. La ciudad de Veracruz** *fué* **fund***ada* **por Cortés. Poco después estalló** (*broke out*) **una insurrección entre sus tropas, pero** *fué* **pronto sofoc***ada* (*quenched*) **por él. También hizo que las naves** *fueran* **quem***adas* **para que ninguno pudiera retroceder** (*so that no one could go back*). **Por fin** (*at last*), **después de muchas luchas en las que los indios** *fueron* **derrot***ados* **por los españoles, la capital** *fué* **tom***ada* **por asalto** (*by assault*) **y todo el Imperio Mejicano** *fué* **somet***ido* **a la corona** (*crown*) **de España.**

On Reflexive and Other Verbs; also Subject, Object, and Reflexive Pronouns

Suena alegremente la campana del colegio a las siete
Sounds (rings) joyfully the bell of the college at

de la mañana. Se oye a varios kilómetros de distancia en
seven *in* the morning. *It is heard* at several kilometres (of)

la campiña fresca que sonríe a los primeros rayos del sol.
distance in the cool countryside which smiles at the first rays of sun.

Nos **levantamos enseguida y nos dirigimos a la gran sala de**
We get up immediately and go towards the big toilet hall

aseo donde cada uno de nosotros tiene su palangana y su
where each one of us has his washing basin and his
toallo, y un cajoncito para el peine, el jabón, los cepillos,
towel, and a little drawer for the comb, the soap, the
etc. También hay duchas de agua caliente y de agua fría,
brushes, etc. There are also showers of hot and cold water,
y baños. Algunos estudiantes, muy pocos, toman una ducha
and baths Some students, very few, take a cold shower
de agua fría —otros *se* bañan : pero los más, *nos* lavamos,
—others take a bath , but (the) most (of us) wash our-
***nos* secamos, *nos* peinamos y volvemos a nuestros cuartos**
selves, dry ourselves, comb (our hair) and return to our rooms
para vestir*nos*.
to dress (ourselves)

Tengo un compañero de cuarto que es muy simpático.
I have a companion of room (room mate) who is
Nos llevamos muy bien. Es aplicado, inteligente y muy
very congenial We get on very well together. He is industrious intelligent
bromista : pero es muy descuidado. Apenas *se* levanta, corre
and very practical joker , but he is very careless Hardly he gets up (when) he runs
a lavar*se*. El dice que *se* lava, pero realmente sólo *se*
to wash (himself) He says that he washes himself, but really he only
humedece la cara. *Se* peina muy mal, *se* pone la ropa de
moistens his face. He combs his hair very badly, he puts on his clothes
cualquier manera, *se* pone la corbata torcida, rara vez
in any way, he puts his tie twisted, he seldom looks
***se* mira al espejo y así no *se* da cuenta, ni se preocupa,**
at himself in the looking glass, and thus he does not realize, neither worries,
de su aspecto. Todo *le* es igual - todo *le* divierte.
about his appearance. Everything is the same for him everything amuses him.
***Se* ríe de las apariencias y hasta de su sombra.**
He laughs at appearances and even at his shadow

Roberto —*le* dije una mañana al regresar del aseo
Robert —I said to him one morning on coming back from the toilet
a nuestro cuarto—¿ te has lavado la cara hoy ? Cualquiera
to our room have you washed your face to-day ? Anyone
diría que no lo has hecho. De lo que estoy seguro es que
would say that you have not done so. Of what I am sure is that
no *te* has peinado.
you have not combed (your hair)

—*Me* he lavado—me contestó · aunque sin jabón, porque
I have washed (myself)— he replied to me—although without soap, because
no lo he encontrado a mano : pero no *me* he peinado, porque
I have not found it handy ; but I have not combed my hair because
rompí el peine, hace unos días, al peinar*me*, y no he tenido
I broke the comb a few days ago, when combing,
tiempo, ni dinero, para comprar*me* otro.
and I have no time nor money, to buy (me) another.

Le* dí mi jabón, *le* presté mi peine y, prometiéndo*le
I gave him my soap, I lent him my comb, promising him
regalar*le* uno nuevo aquel mismo día, *le* hice volver a
to present him (with) a new (one) that very day, I made him
lavar*se* y peinar*se*.
wash (himself) and comb (himself) again.

Otra vez toca la campana a las siete y media llamándonos
Again rings the bell at half past seven calling us
a tomar el desayuno. *Nos* sentamos a la mesa y *nos* preparamos
to take (the) breakfast. We sit at (the) table and we prepare
a despachar los huevos y el tocino con el incitante apetito
ourselves to dispatch the eggs and (the) bacon with the
de la juventud.
keen appetite of (the) youth.

Pása*me* la mermelada, glotón—digo a Roberto que está
Pass me the marmalade glutton I say to Robert who is
a mi lado—si *te* dejan, eres capaz de comér*tela* toda.
by my side —if they (would) let you, you are capable of eating it all

—No debe sorprender*te*—*me* contesta mi madre me ha
It must not surprise you he answers me— my mother has
acostumbrado a las cosas dulces y *me* chupo los dedos de
accustomed me to sweet things and I suck my fingers
gusto cuando como lo que ella *me* prepara en casa Has de saber
with pleasure when I eat what she prepares for me at home You should know
que estoy escribiendo una oda a la mermelada y a mi madre.
that I am writing an ode to the marmalade and to my mother.
¡ Son ambas tan dulces ! Cuando *la* termine *te la* leeré.
They are both so sweet ! When I finish it I shall read it to you

Nos* levantamos de la mesa y, después de pasear *nos
We get up from the table and after taking a walk
unos minutos por el jardín, *nos* dirigimos a las clases.
(for) a few minutes in the garden, we go (towards the) to the classes.
Duran éstas hasta las doce, con algunos intervalos de
These last up to twelve, with some intervals of
descanso : y a las doce y media *se nos* llama a almorzar.
rest , and at half past twelve we are called to lunch.
Nuevamente tenemos clases por la tarde. Todos nuestros
We again have classes in the afternoon. All our
profesores *se* interesan en nuestros estudios, *nos* explican
teachers interest themselves in our studies,
bien las dificultades y *nos* animan cuanto pueden. Yo *me*
they explain to us well the difficulties and they encourage us all they can.
desespero algunas veces con los teoremas de álgebra y
I despair sometimes with the theorems of algebra and
acudo a Roberto para que *me* ayude. El todo *lo* ve claro,
I apply to Robert to help me. He sees everything clear,

todo *lo* **ve fácil, y bondadosa y pacientemente** *me* **explica**
sees everything easy and kindly and patiently he
las cosas una y otra vez hasta que al fin *las* **comprendo.**
explains to me (the) things one and another time until at last I understand them

Después de la comida tenemos libertad para pasear*nos* **(dar un paseo)**
After dinner we have liberty to take a walk
o divertir*nos* **como queremos. Algunas veces, a principios**
or amuse ourselves as we like. Sometimes, at the
del verano, *nos* **paseamos hasta un bonito y tranquilo lago**
beginning of (the) summer, we walk up to a pretty and quiet
a cinco kilómetros del colegio y *nos* **bañamos. Tenemos que**
lake (at) five kilometres from (the) college and we bathe
estar de regreso a las nueve. Con permiso especial *se nos*
We must be back at nine. With special permission we are
permite estar fuera hasta las diez. Entonces *nos* **acostamos.**
permitted to be out up to ten Then we go to bed
Yo *me* **duermo fácilmente y nunca** *me* **despierto hasta que toca**
I go to sleep easily and I never wake up until the bell
la campana a la mañana siguiente.
rings the following morning.

The Impersonal Verbs

¡ Qué tiempo tan malo *hace* **!** *Hace* **frío y nieva. Estos días de invierno en los que** *amanece* **tarde y** *anochece* **pronto son muy tristes. Ayer** *hubo* **una niebla (***fog***) muy espese (***thick***). No se veía a un metro de distancia. El tránsito (***transit***) por las calles era imposible. Las personas se perdían ; los ómnibus, los tranvías, y los automóviles apenas se movían. En algunos casos les** *era necesario* **parar (***stop***) completamente. Por la noche** *heló.* **El hielo estaba tan duro esta mañana que** *era peligroso* **andar y viajar por los caminos**

El verano pasado tambien ha sido malo. *Ha hecho* **muy mal tiempo. Algunos días** *relampagueó y tronó* **(***thundered***) horriblemente. Otros** *hubo vientos* **huracanados (***hurricane winds***) que hicieron muy peligrosa la navegación.** *Parece* **a veces (***It appears sometimes***) que el mundo va a acabarse! Pero no : volverá la primavera y** *hará* **buen tiempo. Volverá abril " con sus lluvias mil " y sus vientos tradicionales. En mayo** *hará* **mucho sol ; los campos estarán llenos de flores , nos pasearemos por entre los árboles de los bosques (***woods***) oyendo los cantos de los pájaros : y en el plácido** *anochecer* **de la entrada del verano, veremos titilar (***twinkle***) las estrellas en el firmamento (***firmament***) trayendo a nuestra memoria una noche en la Alhambra.**

Practice on SER and ESTAR

In the preceding pages there are frequent examples of the uses of these verbs Nevertheless, we give below a good number of them further to illustrate their employment, indicating by means of (1), (2), etc., the heading under which they appear in page 2218

Ser / Estar (1) : **Yo** *soy alegre* **por naturaleza (***by nature***), pero hoy no** *estoy alegre* **porque he recibido muy malas noticias por el correo (***by the post***)**

Estar (1) : **de esta mañana ; es decir, que** *estoy triste.*

Estar N.B. (5) : **Además,** *estoy* **muy** *preocupado* **(***worried***), he** *estado andando* **toda la tarde y**

Estar (1) : *estoy cansado.*

Ser (3) : **Don Ramón Pérez de Ayala** *ha sido Embajador* **de España en Londres.**

Ser (2) : *Es asturiano* **(***Asturian***) ; [Ser (3)]** *es poeta, es novelista* **famoso, [Ser (1)]** *es* **un** *estilista* **de pureza clásica. Una de sus mejores novelas [Ser (1)]**

Ser (1) : *es* **" Tigre Juan."**
Oviedo *es* **la capital de la provincia de Asturias.**

Estar (2) : *Está* **en el Norte de España. En la costa de Asturias [Estar (2)]** *está* **Gijon. [Ser (1)]** *Es* **un puerto magnifico.**

El número de teorías acerca del origen de Colón *es* **(Ser 1)**
The number of theories in regard to the origin of Columbus
innumerable. Se sabe que no *era* **de linaje (Ser 2) noble**
is innumerable. It is known that he was not of noble
En familias de linaje noble de aquel periodo *era costumbre*
lineage. In families of noble origin of that period it was
(Ser 6) conservar un cuidadoso registro de todos los
customary to keep a careful record of all the
miembros de la familia. Se dice que Colón *fué* **educado (Ser 5)**
members of the family. It is said that Columbus was educated
en la Universidad de Pavía, pero *es* **una historia inverosímil.**
at the University of Pavia, but it is an unlikely story
Si Colón hubiera *estado* **(Estar 2) en aquella Universidad,**
If Columbus had been at that University, he would
habría aprendido a leer y a escribir en latín. Se cree
have learned to read and to write in Latin. It is believed
que Colón *era* **de Génova (Ser 2). Cuando** *era* **joven (Ser 1)**
that Columbus was from Genoa. When he was young he
estuvo **en Portugal (Estar 2). En 1486** *fué* **presentado (Ser 5)**
was in Portugal. In 1486 he was presented to
a la Reina Isabel de Castilla. *Estuvo* **(Estar 2) después en**
the Queen Isabella of Castile. He was afterwards at
Salamanca. Finalmente Colón *fué* **protegido (Ser 5) por**
Salamanca Finally Columbus was protected by
esta Reina. Salió en su primer viaje de descubrimiento
this Queen. He left on his first voyage of discovery
del puerto de Palos, que *está* **(Estar 2) en la provincia de Huelva.**
from the port of Palos, which is in the province of Huelva.
Colón *estuvo* **navegando (Estar 5, N.B.) durante 71 dais, al**
Columbus was navigating during 71 days, at the end of
cabo de los cuales *fué* **descubierta (Ser 5) la isla de**
which was discovered the Island of
Guanahami, hoy San Salvador.
Guanahami, today San Salvador.

Examples on Ser 6

Para aprender bien una lengua extranjera
In order to learn well a foreign language
es necesario **estudiar metódicamente.** *Es esencial*
it is necessary to study methodically. It is essential
aprender de memoria, no solamente palabras, sino
to learn from memory, not only words, but whole
frases enteras. *Es fácil* **recordar las palabras que se**
phrases. It is easy to remember the words which
parecen a las de la lengua madre. *Es difícil* **aprender**
resemble those of the mother tongue. It is difficult
sin poner atención y sin concentrar en el estudio.
to learn without putting (paying) attention and without

Es práctico **escribir una y otra vez palabras largas y**
concentrating in the study. It is practical (helpful) to write one and another time (occasionally)
difíciles, y los verbos en todos sus tiempos. Y es muy
long and difficult words, and the verbs in all their tenses. It is
***útil*, sobre todo, leer buenos libros de autores renombrados.**
very useful, above all, to read good books of renowned authors.
Es bueno **repasar periódicamente lo aprendido.** *Es malo*
It is good to revise periodically what (has been) learnt. It is bad
dejar interrumpido el estudio por largo tiempo. *Es mejor*
to leave the study interrupted for (a) long time. It is better to
aprender poco y regularmente, que mucho a intervalos
learn little and regularly than much at irregular
irregulares. *Es conveniente* **consultar el diccionario**
intervals. It is convenient to consult the dictionary in
en casos de duda. *Es importante* **escuchar con atención**
cases of doubt. It is important to listen with attention
a los naturales (nativos) del país cuya lengua se está
to the natives of the country whose language one is
aprendiendo.
learning.
Es posible **aprender fácilmente cuando se es joven.**
It is possible to learn easily when one is young.
Sin embargo, nunca *es tarde* **para aprender. "Más vale tarde que nunca."**
Nevertheless, it is never too late to learn. "Better late than never."

On SABER, CONOCER and PODER

Sé **que Vd. tiene un hermano mayor, pero no le** *conozco.*
I know that you have an elder brother, but do not know him.
Sé **tocar el piano, pero hoy no** *puedo* **tocarlo porque**
I know (how to) play the piano, but I cannot play
tengo reuma en las manos.
it today because I have rheumatism in my hands.
Sin *saber* **por qué entró en la biblioteca y allí** *conoció*
Without knowing why he entered the library and
a Menéndez Pelayo.
there he knew Menéndez Pelayo.
Este documento es auténtico, *conozco* **la firma**
This document is authentic, I know the signature
del Presidente.
of the President.

¿ *Saben* **Vds. el cuento del barquero** (boatman) **y el filósofo ? Es poco más o menos así : Un filósofo, teniendo que atravesar un lago** (lake), **entró en una barca** (boat) **y empezó a hablar con el barquero. Después de unos minutos, el filósofo preguntó al barquero :**

¿ *Sabe* **Vd. filosofía ?**

—No señor—contestó el barquero.

Entonces—dijo el filósofo—usted ha perdido mucho tiempo de su vida. ¿ Sabe Vd. astronomía ?

—No señor—volvió a decir el barquero.

—Entonces Vd. ha perdido gran parte de su vida—añadió el filósofo.

NOTE. VOLVER + *a* + infinitive—the action of the infinitive in the tense expressed by VOLVER + *again*. Thus: **vuelve a escribir**—*he writes again*, **Volvió a escribir**—*he wrote again*, **vuelve a decir**—*he says again*, and **volvió a decir**—*he said again*.

Así *siguió* **el filósofo preguntando, ¿** *Sabe* **Vd. matemáticas ?, ¿** *sabe* **Vd. geografía ? etc., etc., y el pobre barquero decía siempre, no, no y no. El filósofo comentaba seguidamente** (commented *immediately*), **" Vd. ha perdido gran parte de su vida."**

Al cabo de un rato, se desencadenó[1] (At the end of a while broke out) **una tempestad y la barca comenzó a zozobrar** (capsize).

¿ *Sabe* **Vd. nadar ?—gritó el barquero.**

—No—respondió el filósofo.

Entonces, Vd. va a perder ahora *toda* **la vida, señor filósofo—dijo finalmente el barquero.**

[1]**DESENCADENAR** **CADENA**—*chain*

ENCADENAR—*to chain*

DESENCADENAR—*to unchain, to break loose, to break out*

La única cosa que *sé*, **es** *saber* **que nada** *sé*, **y esto me**
The only thing that I know is to know that I know nothing,
distingue de los demás filósofos, que creen *saberlo todo.*
and this distinguishes me from the other philosophers, who believe they know all.

LESSON 7

Adverbs, Prepositions, and Conjunctions

An adverb is a word used to qualify any part of speech except a noun or a pronoun.

Four simple rules enable one to form all the adverbs or adverbial expressions ever likely to be required.

(1) Add **-mente** to the feminine of all adjectives ending in **o.**

(2) Add **-mente** to the masculine of all adjectives which have no separate form for the feminine.

(3) Use the phrase **de una manera . . .** followed by the adjective in the feminine. (Literally : *in a . . . manner.*)

(4) Use **con** (*with*) followed by the noun.

Examples of (1) : **Industrioso,** *industrious.* Adverb: **industriosamente,** *industriously* ; **caro,** *dear* ; **caramente,** *dearly* ; **público,** *public* ; **públicamente,** *publicly.*

Examples of (2) : **útil, útilmente,** *uesful, usefully* ; **fácil, fácilmente,** *easy, easily.*

Examples of (3) : **de una manera industriosa,** *in an industrious manner* ; **de una manera muy clara,** *in a very clear manner.*

Examples of (4) : **con facilidad,** *with facility* ; **con claridad,** *with clarity* ; **con industria,** *with industry.*

When several adverbs ending in **-mente** would follow one another it is customary to add the **-mente** only to the final one : *He speaks clearly, easily, and rapidly,* **Habla clara, fácil y rápidamente.**

In adverbs formed with **-mente** each part retains its original accentuation : **públicamente, perfectamente,** *publicly, perfectly.* **Orgullosamente,** *proudly.*

Another useful phrase is **de un modo** to vary **de una manera** (it means almost the same thing) : **de un modo valiente,** *in a valiant manner.*

As in English, an adverb may qualify an adjective : **Ella es extraordinariamente hermosa,** *She is extraordinarily beautiful.*

The Spanish adverb follows the simple verb or the past participle in compound tenses and precedes an adjective or a direct object noun: **Hablo bien,** *I speak well.* **He hablado bien,** *I have spoken well.* **Hablo bien inglés,** *I speak English well.*

Adverbs follow the same rules as adjectives to form the comparative and superlative (*see* pages 2207-08): **Fácilmente, más fácilmente, lo más fácilmente,** *easily, more easily, most easily.* **Claramente, más claramente, lo más claramente** or **muy claramente.**

A list of the most frequently recurring adverbs and adverbial phrases will be found in pages 2240-41. (It does *not* include the adverbs ending in **-mente** which are made from adjectives.)

Prepositions

A Preposition is a word placed before a noun to show in what relation the person or thing denoted thereby stands to something else.

The grammar of the Spanish language is, on the whole, straightforward and logical, following a number of rules and principles which can be enunciated with reasonable certainty. But when we come to the prepositions we encounter difficulties which are not merely so to the foreign student but to the cultured native speaker or writer. So careful a scholar as Baldomero Sanin Cano says in his "Grammar":

> There are no precise or general rules in Spanish for the use of the prepositions . . . assiduous practice following the best usage is the only way to master this section of Spanish grammar . . . good writers often differ as to what is the best usage

In other words, mastery of the prepositions comes only by care and experience.

A list of the most frequently recurring prepositions will be found in p. 2241, and it is advisable to memorize them first before proceeding to consider the worst pitfalls. Then consider what now follows (if it appears somewhat vague, it is due to the difficulty of the subject):

A, *to, at*: its basic meaning is the point to which anything reaches or tends, and hence it is used to indicate *direction* both in regard to place and time.

Voy a la casa, *I go to the house.* **A la derecha, a la izquierda,** *to the right, left.* **De calle a calle,** *from street to street.* **A pie, a mano,** *on foot, by hand.*

It is used for the *manner* of doing something, for the *instrument* with which something is done, for *price, rate,* and *resemblance,* and for many expressions of *time.* After verbs of depriving it corresponds to English "*from.*"

Memorise the following:

Sentarse a la mesa, *To sit down to table.* **A mediodía, a medianoche,** *At midday, midnight.* **A la llegada, salida,** *On arrival, departure.* **A ojos vistos,** *With open eyes.* **¿ A cuánto se vende ?** *At how much does it sell ?* **A cinco pesos el metro,** *At five pesos the metre.* **A la española, inglesa,** *In the Spanish, English manner* (*style*) **Uno a uno, dos a dos,** *One by one, two by two.* **Poco a poco,** *Little by little.* **Quité al marinero su sombrero,** *I took away from the sailor his hat.* **A bordo de un vapor,** *On board a steamer.*

See also p. 2221 for **a** after certain verbs and for its use with a personal object. (**A** is the most confusing preposition; compared with it the others are not difficult.)

DE, *of, from*: the basic meaning is *direction from* some thing, place, time, or condition. Also used for the *material* of which something is made, for *ownership* or *relation* of a part to a whole, the *use* for which something is intended. Thus:

Del Río de La Plata hasta el Brasil, *From the River Plate to Brazil.* **Don Quijote de la Mancha, Dulcinea del Toboso.** **De vez en cuando,** *From time to time.* **Una silla de madera,** *A wooden chair.* **Las obras de Pérez de Ayala,** *The works of Pérez de Ayala.* **La corrida de toros,** *The bull-fight.* **La cabeza del perro,** *The dog's head.* **Un caballo de caza,** *A horse for hunting.* **Vengo de Madrid,** *I come* (or *am*) *from Madrid.* **Hablo de memoria,** *I speak from memory* **¡ Pobre de mí !** *Poor me !*

De is also frequently used after a superlative to translate English "*in*":

Río Janeiro es la ciudad más populosa del Brasil, *Rio de Janeiro is the most populous city in Brazil.*

CON, *with*: primary meaning, accompaniment. Also: instrumentality, association, addition.

Llego con mi hermano, *I arrive with my brother.* **Lo hago con mis propias manos,** *I do it with my own hands* **Café con leche,** *coffee and milk* (*café au lait*). It sometimes means "nevertheless" **Con todo eso,** *for all that.* **Es rico, con todo no lo quiero mucho,** *He is rich, yet I don't like him.*

DESDE, *from*: is used for "*since*" when applied to time.

Desde que lo vi la semana pasada, *Since I saw him last week.* **Desde Londres hasta Liverpool,** *From London to Liverpool*

EN, *in*: is used for time, place, and manner.

Cuando lo vi en Córdoba el verano pasado hablaba en serio, *When I saw him in Cordoba last summer he spoke in earnest.* It is used with a present participle to denote an action immediately preceding another action. **En llegando a casa le quité la espada,** *The moment I reached home I took his sword from him.*

HASTA means *until, up to.* **HACIA** means *in the direction of.*

Desde Buenos Aires hasta Mendoza, *From Buenos Aires right up to Mendoza.* **Hasta mañana,** *until tomorrow.* **Hasta luego,** literally, *until soon,* is a very common expression meaning "*Au revoir, and I hope we'll soon meet again.*" **Hasta la vista,** *Until we see each other again.* **Hacia el Norte hay una tempestad,** *In the North there is a storm* **Hacia allí está el parlamento,** *In that direction is parliament.*

POR and **PARA** both are freely translated by "*for,*" but in Spanish their meaning is more definite. **Para** is used for *direction,* motion towards, goal or end to be served. Thus:

Hay que trabajar para comer, *One must work in order to eat.* **El vapor para Valparaiso,** *The steamer for Valparaiso* **Para eso,** *for all that.* **Por** is used when referring to an equivalent, or *in return for* · **Me**

dió su libro por el mío, *He gave me his book for (in exchange for) mine.* It also denotes length of time, in the neighbourhood of a place or through one, manner and motive: **Estaré de viaje por un año,** *I shall be travelling for (during) a year.* **El aeroplano pasa por París a las ocho,** *The aeroplane passes Paris at eight o'clock.*

NOTE ALSO. **Lo hizo por ignorancia,** *He did it from ignorance.* **Pasar por la calle,** *to walk along the street.* **Lo hago por fuerza,** *I do it by force (strength).* **Vendió el caballo por cien pesetas,** *He sold the horse for one hundred pesetas.* **Me ausento de Lima por un mes,** *I am (shall be) absent from Lima for a month.* **Mañana por la mañana,** *tomorrow morning*

¡ Por Dios ! *Good gracious !* (In Spanish-speaking and, indeed, all Roman Catholic countries the name of the Deity is used as a harmless expletive) **Voy por pan,** *I am going (to fetch) bread.* **Por lo que dice,** *to judge from what he says.* **Por grande que sea,** *however big it may be.* **Por ahora,** *for the time being.* **Por lo que a mí hace,** *In so far as I am concerned.*

SEGUN : *according to.* **Según las circunstancias,** *according to circumstances.* This is the only preposition which can be used by itself.

¿ Cuándo llegará Vd. ? *When will you arrive ?* **Segun,** *That will depend.* And note : **Segun se ve,** *as can be seen (on the face of it).*

SOBRE : *on, upon.*

Sobre la mesa, *on the table* **Escribo sobre derecho,** *I write about law.* **Hemos hablado sobre las cosas del dia,** *We have spoken about current affairs.* **Tomo sobre mí mucho trabajo,** *I take much work upon myself*

Now see p. 2241 for complete list.

Conjunctions

Conjunctions are words used for connecting either words or sentences. The principal Spanish conjunctions are :

Pero, mas, sino, equivalent to English " *but.*"

O, *or.* This becomes **u** before words beginning with **o** or **ho.**

Y, *and.* This becomes **e** before words beginning **i** or **hi.**

Ni, *nor, neither* ; **si,** *if, whether* ; **que,** *that.*

General usage corresponds approximately to that in English, and only **QUE** and **SINO** need be singled out for special attention. Remember that **sino** consists of **si,** *if,* and **no,** *not.* If we present an alternative in a sentence which contains words which show that a negative answer is expected, then the English word " but " is translated by **sino** ; also when the first clause in a sentence is negative. Thus :

No le he visto a él, sino a su hermano, *I have not seen him, but his brother.*

¿ Cuándo deberemos ir sino ahora ? *When shall we go if not now ?*

If a verb follows in the second clause, then **PERO** is used :

No le he visto a el, pero he visto a su hermano, *I have not seen him, but I have seen his brother*

No tengo sino un sombrero, *I have only one hat.* **No lo sabia sino de memoria,** *I only knew it by memory* **No he estado en España, sino dos semanas,** *I have been in Spain only two weeks*

The conjunction **QUE** must always be used in Spanish, even where it may be omitted in English. Thus, sentences such as " I think he is a good man," " I believe it will rain," " John replied he did not know," etc., must be rendered, " I believe *that* it will rain," " John replied *that* . ." etc. , **Creo que va a llover (or lloverá). Contestó Juan que no conocía,** etc.

A list of the most frequently recurring conjunctions will be found in p. 2241. and they should be well memorised ; they are among the most frequently recurring words in the language.

LESSON 8

Word Building and Idioms

It has been emphasised in the introductory remarks in Lesson 1 that while Spanish is the easiest of languages if the student is content with a good, practical working knowledge, its real difficulty is to be found in the next stage. Knowing how and where to use an augmentative or a diminutive is a test of both knowledge and intelligence. Word building by the use of endings is therefore the main subject of this Lesson.

Endings

In Spanish and English there are many thousands of words which have a common parentage in Latin, and they tend to resemble one another. It is hardly necessary to have to be told that **futuro** means *future.* At the same time, even at this stage of learning, it is as well to be able to recognize certain endings in Spanish which are frequently equivalents for English endings Of these the commonest are

(*a*) **Nouns:**

English ending	*Spanish ending*	*Gender*
-age	-aje, as in **personaje**	m.
-ct	-cto, as in **conducto**	m
-ism	-ismo, as in **comunismo**	m.
-ment	-mento, as in **parlamento**	m.
-cy	-cia, as in **abundancia**	f.
-ion	-ión, as in **religión**	f
-tion	-ción, as in **acción**	f
-tude	-tud, as in **multitud**	f.
-ty	-dad, as in **falsedad**	f.

(*b*) **Adjectives :**

-ate	-ado, as in **duplicado.**
-acious	-az, as in **sagaz, tenaz**
-arious, -ary	ario, as in **precario, contrario**

(*c*) **Verbs**

-ize	-izar, as in **civilizar**
-ate	-ar, as in **fumigar**
-fy	-ficar, as in **fortificar**

When an English word with the ending in the first column above has to be translated into Spanish, it is nearly always safe to do so by adding the endings in the second column,

making at the same time whatever orthographic changes) may be necessary. Remember that there are no double letters in Spanish (excepting **rr, ll, cc**). The most useful orthographic changes to remember are :

English	*Becomes in Spanish*	
qu	**cu**	**consecuencia**
th	**t**	**teatro**
ph	**f**	**filologia**
ch	**c**	(or **qu** before **e** and **i**), **caracter, caracteristico**
s, initial	**es-**	**estricto**
y	**i**	**simpatia**

Word Building

The capacity of Spanish for making *new words* by adding *new syllables* is one of the principal characteristics and beauties of the language, but it is a difficulty for the foreigner as well as being an encouragement. It is proposed here to treat only a few general principles, more as examples of what can be done than as an effort to exhaust the subject (for which a treatise would be required). The syllables added to Spanish words in order to change their meaning are :

(*a*) the *Augmentatives* which increase or intensify the meaning of the original word ;

(*b*) the *Diminutives* which act in a contrary sense, and

(*c*) a number of what may conveniently be called *Derivative Suffixes*.

There are also a number of *Prefixes*, but, as they are nearly all common to both English and Spanish, they are for practical purposes self-explanatory.

1. Augmentatives. The endings **-ÓN, -AZO, -OTE, -AJO, -ACHO, -UCHO** *add* to the original meaning (*size*, *degree*, *quality*) and may modify it by a still further addition of clumsiness, grotesqueness, or some other quality to excite either admiration or contempt.

-ón, -óna merely increase the original meaning in regard to size. Thus : **cuchara,** *a spoon* ; **cucharón,** *a ladle*. **Soltero,** *a bachelor* ; **solterón,** *a "crusted" bachelor*.

-azo, -aza are also simple augmentatives. **Hombre,** *man* ; **hombrazo,** *a big man*.

-ote, -ota are augmentatives usually in a depreciative sense. **Feo,** *ugly* ; **feote,** *extremely* or *frightfully ugly*. **Una feota,** *a "fright."*

-ajo adds a strong element of contempt to the original meaning. Thus : **Latin,** *Latin* ; **Latinajo,** *Latin jargon, dog-Latin*.

-acho, -ucho are depreciative but not exactly contemptuous. Thus : **Vino,** *wine*. **Vinacho,** *a very poor wine*. **Casa,** *a house*. **Casucha,** *hovel*.

-uco, -uca are used in a few cases instead of **-ucho, -ucha**, but it *may* have in it an element of strong contempt when used for men or women. **Casa,** *house*. **Casuca,** *a shanty*. Note the following : **Fraile,** *friar*. **Frailuco,** *a poor friar*. **Hermano,** *brother*. **Hermanuco,** *a poor member of a religious brotherhood*.

2. Diminutives. -ITO, -ICO, -ILLO, -UELO, -ETE. To these are sometimes added still further diminutives :

(*a*)	**-ito**	**-cito**	**-ecito**	**-ececito**	The last are rare
(*b*)	**-ico**	**-cico**	**-ecico**	**-ececico**	
(*c*)	**-illo**	**-cillo**	**-ecillo**	**-ececillo**	
(*d*)	**-uelo**	**-zuelo**	**-ezuelo**	**-ecezuelo**	
(*e*)	**-ete**	**-cete**	**-ecete**	. . .	

The above table is given for reference, as some of these endings are rarely used and have meanings too subtle to be safely employed by the foreigner. Indeed, the foreigner who dares to employ any of the above excepting **-ito, -cito** and perhaps **-ecito** may be courting real bodily danger ! This will become apparent in considering the meaning of the diminutives, which is given below for reference and to assist in understanding Spanish :

(*a*) **-ito, -cito, -ecito, ececito** indicate *smallness* to which is added a sense of endearment, prettiness, pleasantness, etc. They may sometimes be found to give a flavour of irony, especially with names of prominent men.

Viejo, *old man*. **Viejito,** *little old man*. **Viejecito,** *nice little old man*

These endings may be added to baptismal names of persons to indicate affection, and to almost any other words with a *pleasantly intensifying* effect.

Thus **Miguelito,** *Mike*. **Dieguito,** *Jimmie*. **Juanito,** *Jack*. **Voy ahora mismito,** *I'm going this very second*. **Prontito,** *very soon*. **Juntito,** *near by, close*. **Lejitos,** *some distance away*. **Enseguldita,** *immediately*. **Hablo un poquito el Español,** *I speak Spanish just a little* (**Un poquitito,** *a very little*.)

(*b*) **-ico, -cico, -ecico** have the same meanings as (*a*) but more frequently contain an element of sarcasm.

(*c*) **-illo** decreases size and takes away from quality—objectively and without either malice or love.

Cigarro, *cigar*. **Cigarillo,** *cigarette*
Chico, *small*. **Los chiquillos,** *the little children*.

(*d*) **-uelo,** etc. This generally belittles *with contempt*. **Pintor,** *a painter, artist*. **Pintorzuela**. *a dauber*.

(*e*) **-ete,** etc. Often depreciates as well as decreases size or quality. **Burla,** *joke, trick*. **Burleta,** *a nasty trick*.

Four other diminutives of less importance will sometimes be met : **-ejo, -in, -ino, iño.** The first is contemptuous, the others are dialect forms.

Two points will be observed in connexion with both augmentatives and diminutives : the last vowel of an original word is dropped before the ending is added ; and there may be a slight orthographic change in the original. Thus :

Bueno, *good*. **Bonazo,** *good big fellow*. **Chico, chiquillo. Pedazo,** *piece*. **Pedacito. Lengua,** *tongue, language*. **Lengüecita.**

It will be appreciated that these last are our old friends, the orthographic changes made to preserve the original *sound* when an inflexion is added.

3. Derivative Suffixes. This is, again, a subject upon which a considerable treatise might usefully be written. Here we can only deal with a few of the suffixes, merely to indicate the extraordinary flexibility and richness of Spanish, and as an illustration of a few of the

general principles involved. The suffixes chosen for this purpose are of fairly frequent occurrence.

-ADA : expresses the *capacity* or duration of what is denoted by the original noun.

Cuchara, *spoon*. **Cucharada**, *spoonful*
Mano, *hand*. **Manada**, *handful*

Also indicates a class or collection : **caballo**, *horse*. **Cabalgada**, *cavalcade*.

And it denotes the stroke given with an instrument **cuchillo**, *knife*. **Cuchillada**, *cut, gash*.

-ada, **-ida**. These past participle endings indicate the *completed action*. **La entrada**, *the entrance*. **La salida**, *the departure*. **La llegada**, *the arrival*. **La venida**, *the coming*.

-ERO : indicates the *person* who is in charge of something, or responsible for an action.

Cabra, *goat* **Cabrero**, *goatherd*
Escudo, *shield* **Escudero**, *shield-bearer, squire*
Rancho, *ranch* **Ranchero**, *ranch-owner*
Toro, *bull* **Torero**, *bull-fighter*.

-ero also denotes the place or article for containing something :

Sal, **salt**. **Salero**, *salt-cellar*
Azúcar, *sugar* **Azucarero**, *sugar-bowl*

And it denotes a dealer :

Cuchillo, *knife* **Cuchillero**, *cutler*
Libro, *book* **Librero**, *bookseller*
Zapato, *shoe* **Zapatero**, *shoemaker*

-ÍA and **-RÍA** : denote the *place* of business or the *actual trade or business* of the person :

Libro, *book* **Librería**, *bookseller's shop* (also the business of bookselling).

Reloj, *watch clock*. **Relojería**, *clock-trade, clock or watch shop*. **Zapatería**, *shoe-shop, shoe-trade*.

This ending forms abstract nouns from adjectives : **cortés**, *courteous* **Cortesía**, *courtesy*. **Bizarro** in Spanish means *gallant, high-minded* . **bizarría**, *gallantry*. **Mejor**, *better* **Mejoría**, *betterment*

-ERO and **-ÍA** are the two endings which the beginner will find most useful, especially if he intends to travel in Spanish-speaking countries

The following list of derivative suffixes may be memorized at leisure, and treated at this stage as for reference only :

-ADOR, **-EDOR**, **-IDOR** : the person who performs the actions of the verb. **Beber**, **bebedor**.

-AJE : corresponds to English *-age* in such words as **Pilotaje**, *pilotage*. **Carreta**, **carretaje**, *cart cartage*.

-ANZA : forms abstract or verbal nouns **Matar** *to kill*. **Matanza**, *killing, slaughter*

-AR : denotes a collection **Manzano**, *apple tree*. **Manzanar**, *apple orchard*.

-ARIO : often corresponds to English ending *-ee* **Consignar**, *to consign* **Consignatario**, *consignee*. **Concesionario**, *grantee*, the person to whom a concession is made.

-AZGO : the office, function or jurisdiction of the person indicated in the original noun. **Almirante**, *admiral*. **Almirantazgo**, *Admiralty*. **Hermano** *brother*. **Hermanazgo**, *Fraternity*

-AZO : blow, stroke, or wound. **Bala**, *bullet* **Balazo**, *bullet wound*. **Zapato**, *shoe*. **Zapatazo**, *kick, or blow with a shoe*.

-DERO : place. **Fondear**, *anchor*. **Fondeadero**, *anchorage*. **Matar**, *to kill*. **Matadero**, *slaughter-house*. Also forms adjectives from verbs : **Casar**, *to marry*. **Casadero**, *marriageable*.

-DIZO : fitness, capability, susceptibility. **Beber**, *to drink*. **Bebedizo**, *fit to drink*.

-DUMBRE : forms abstract nouns from adjectives. **Mucho**, *much*. **La muchedumbre**, *multitude, crowd*. **Cierto**, *certain*. **Certidumbre**, *certainty*

-EAR : forms verbs from nouns, and makes verbs frequentative. **Ventana**, *window*. **Ventanear**, *to be continually looking out of a window*. **Borracho**, *drunk*. **Borrachear**, *to be drunk very often* -ear verbs form nouns in **-eo**. **Rodear**, *to go round* **Rodeo**, *a round-up* (in Spanish America, *a tournament*).

-EDO, **-EDA** : the place where something grows. **Viña**, *vineyard*. **Viñedo**, *vine district*. **Árbol**, *tree*. **Árboleda**, *grove*.

-ERA : similar to *-ero*. **Tabaco**, *tobacco*. **Tabaquera**, *pouch*.

-EZ, **-EZA**, **-IENTO**, **-INO**, **-IZO**, **-OSO**, **-UDO**, **-UNO** : all these form adjectives and nouns that are generally recognizable from the original word.

-MENTO, **-MIENTO** : form nouns from verbs. **Nacer**, *to be born*. **Nacimiento**, *birth*. **Casar**, *to marry*. **Casamiento**, *marriage*

-ÓN : forms adjectives from nouns and verbs, with a meaning which has something of the augmentative in it **Burlar**, *to joke*. **Burlón** (adj.), *jocular, waggish*.

The student is advised not to regard the equivalents given for all these derivative suffixes as strictly accurate. They give but a general indication of the meaning, which sometimes varies in accordance with usage—always the final arbiter in all such matters.

To give some indication of the richness of Spanish, the word **tierra**, *land*, and its derivatives are quoted by an authority who gives sixty-one other words formed from it. Thus :

terreno, *ground* **terráceo**, *made of earth* ; **terradillo**, *small terrace* ; **terrín**, *peasant* , **terroncillo**, *small clod* , **terraje**, *rent of land* , **aterraje**, *drifting ashore* ; **desterrado**, *exile, outcast* **desenterrador**, *body-snatcher*, etc

If we add a number of possible inflexions to these words (feminines, diminutives, augmentatives, etc.) the list could be extended to the neighbourhood of two hundred words—all deriving from this one word **tierra.** The student will (wisely) conclude from this that if it is a comparatively straightforward business to get a working knowledge of Spanish, such as will carry him through life for most practical purposes, to know it thoroughly is quite another matter. This warning is uttered so that the learner may not be misled by the simplicity of the grammar into believing that it is *always* an easy language. It is nothing of the sort !

Idioms

An idiom is a turn of phrase peculiar to a language. Thus, when we say in Spanish **dar un paseo**, *to take a walk*, this is an idiom. The most important idiomatic expressions have been mentioned already under the different parts of speech, as in Spanish most of the idioms are peculiarities of usage rather than completely different phrases, as in French.

Examples :

Tengo que irme	*I must go.*
Tener hambre, sueño, miedo, vergüenza, sed.	*To be hungry, sleepy, afraid, ashamed, thirsty.*
Tener razón, no tener razón.	*To be right, wrong*, etc.
Tengo 30 años.	*I am* 30.
Tengo frío, calor.	*I am hot, cold.*

Tenga Vd. la bondad le decirme.	*Be so good as to tell me.*
¿ Qué quiere Vd. decir ?	*What do you mean ?*
¿ Qué tiempo hace ?	*What is the weather like ?*
Hace frío, calor.	*It is hot, cold.*
Haga por venir.	*Try to come.*
Hace una semana, un año	*A week, year ago*
¿ Qué hay ?	*What is the matter ?*
No hay de que.	"*Not at all*" in reply to "*Thank you,*" etc.
¿ Cuántos años teine Vd. ?	*How old are you ?*
No se sabe.	*It is not known.*

See also Lesson 6 (page 2221) under " Some idiomatic usages of verbs."

Forms of Address and Family Names

Spanish-speaking peoples are more formal and polite than we are in forms of address. Nothing strikes the visitor to Spain more forcibly than the dignity and courtesy with which two peasants will speak to one another, and this courtesy permeates society. The same can be said of Spanish America. Hence, it is of the utmost importance for the foreigner to make himself familiar with usage and custom ; and he should do so fairly early in his studies. English " bluntness " should be avoided, as it is merely regarded as a lack of delicacy.

The word **Usted** (generally written **V.** or **Vd.**, plural **Ustedes,** written **VV.** or **Vds.** It is also written **Vmd., Vmds., Ud., Uds.**) is the general equivalent for the English word *YOU* and it is the form of address which should always be used by the foreigner in addressing adults. **Usted** is a contraction of **Vuestra merced** (*pl.* **Vuestras mercedes**) meaning *Your Grace*, and therefore requires the verb to be in the third person : **¿ Tiene Vd. un fósforo ?** *Have you a match ?* When the abbreviation is met in writing it should always be read in the full form **Usted,** just as in English we read Mr. and Dr. as Mister and Doctor, etc.

Tú, *thou,* is used between relations, intimate friends, in addressing children, the Deity, animals ; and also in speaking to servants, or by officers speaking to privates, etc. It does not always imply a sense of superiority on the part of the speaker.

Vosotros is the plural of **Tú,** and is the form used by public speakers, preachers, or to address two or more people to whom **Tú** would apply.

The word **Vd.** should be used frequently in conversation, at least once in each sentence ; but, having used it once, there is seldom any need to repeat it in the same sentence :

Vd. tiene un sombrero, pero no tiene zapatos, *You have a hat, but you have no shoes.*

It should also be used to clarify or emphasize :

Le digo a Vd. que no tiene razón, *I tell you that you are not right.*

Sí and **se** are nominative and accusative reflexives for **Usted : Delante de sí,** *Before you.* **Vd. se casó,** *You got married* (*see* p. 2216)

Mr. and *Sir* are expressed by **Señor** and **Caballero,** the latter being a little more formal than the former. **Señor** may have in it an indication of respect (as when a servant speaks to the head of a house or a guest). Also, **Señor** is used *only with surnames* : **Señor Fernández** (or **El Señor Fernández**). **Caballero** is used between equals. Furthermore, **caballero** is probably more widely employed in Spanish America than in Spain.

Don and **Doña** (*Mr., Mrs.*) are used *only with Christian names* : **Don Carlos, Doña María. Don** may be preceded by **Señor** and **Doña** by **Señora** (*Mrs.*) or **Señorita** (*Miss*). **Señor Don Carlos, Señora Doña María.** Thus, a gentleman named **Carlos Fernández** can be addressed as follows :

Señor Don (or D.) Carlos Fernández.
Señor Fernández. Don Carlos Fernández.
Or Don Carlos.
And spoken of as **El Señor Fernández.**
Similarly **Señora de Larrañaga, Señora Doña María de Larrañaga, Doña María de Larrañaga, or Doña María.**

Let us imagine that **Sr. D. Carlos Fernández** marries **Sra. Doña María Larrañaga.** If they wrote their names in full they might be as follows : **Señor Don Carlos Fernández y Castro** (**Fernández** would then represent his father's name and **Castro** his mother's) and **Sra. Doña María Larrañaga y Villegas.** The children would take the family names of both parents, and be called **Fernández y Larrañaga.** The principal names of the son might thus be **Juan Fernández.**

This use of family names is common and accounts for the long names sometimes to be met in Spanish. The names of estates were often added to family names. Basque names are often formidable : **Señor Don Guillermo Echegaray de Guipúzcoa y Urruticoichea.**

Señorito is used for *Master*, and is only used by servants or with the article—**el señorito,** *the young gentleman.* **Señorita** is used for English *Miss.* **Señor** is used for *Lord* and **Señora** (in **Nuestra Señora**) for *Our Lady* (meaning the Virgin Mary). Note also : **Don Fulano de tal,** *Mr. So-and-so* (*Monsieur un tel* in French).

In speaking directly to a person always use **Señor, Señora,** etc. : **" Buenos dias, Señor," " Buenas tardes, Señor Doctor."** (**Señor Profesor,** etc.) And in Spanish America say : **" ¿Cómo está Vd., caballero? "**

NOTE. **El Presidente Alcalá Zamora,** *President Alcalá Zamora* ; **El General Martínez Anido,** *General M.A.* ; **El Padre Fernando,** *Father Fernando* ; **El rey Felipe II,** *King Philip II* ; **La Señora Fortuna,** *Dame Fortune* ; **Es un verdadero caballero,** *He is a true gentleman* , **Mi señora** (or **esposa**), *My wife.* **Mi señor** means " *my master,*" and not " *my husband,*" which would be **mi marido.**

One can be very polite and say **Señor caballero.** But remember that **caballero** is never used with a name —only alone or with **señor**

Correspondence

The date is written thus: **26 de Setiembre de 1934. 1° de Enero de 1957.** (The first of the month always **El primero.** Other days simply the number.)

A formal opening: **Muy Señor mío. Muy Señores míos. Muy Señores nuestros** (the latter when writing from a firm to a firm). **Muy Señora mía. Distinguida Señorita.**

A moderately familiar opening: **Muy estimado Señor Fernández,** or **Muy Señor mío y amigo.** Or, **Distinguido amigo.**

A familiar opening: **Mi querido amigo. Querido amigo. Querido Fernández.**

A formal ending to a gentleman: **S.S.S.** and then, immediately above the signature, **Q.B.S.M. (Su seguro servidor, que besa su mano,** *Your obedient servant, who kisses your hand.*)

A formal ending to a lady: the same, with **Q.B.S.P. (que besa sus pies).**

A moderately familiar ending: **Se repite de Vd.** (if there has been previous correspondence), and then, above the signature, **Afmo. atento y S. S.** If no previous correspondence: **Se ofrece a V. . . .**

A familiar ending: **Saluda a Vd. muy atentamente, su afmo. amigo.** Or, **Le saluda su buen amigo.** (Or, **Le abraza su buen amigo.**)

It is usual for one correspondent to refer to another's letter as **la estimda de Vd.**

In Spanish America the **Q.B.S.M.** is omitted, and the expressions **Su atento servidor, su seguro servidor,** or **Su muy atento y seguro servidor** are used alone.

PRACTICE IN CONVERSATION

In the conversations which follow only those words are used which the student has already met. He should therefore be equipped to read them without great difficulty. The sentences which follow are in an approximation to "Basic" Spanish: that is, they are constructed in accordance with a simple but good grammar, and with simple, essential words.

La Estación del Ferrocarril (*1939*)

Mozo : ¿Desea Vd. un mozo, Señor ?

Don Fulano de Tal : Sí. Espero coger el (tren) de las once treinta para Birmingham. ¿ Cuánto tiempo tengo ? (Don F. de T. = Mr. Everyman, Mr. So-and-So.)

Mozo : Diez minutos. El tren entra en la estación ahora. ¿ Tiene Vd. billete ?

Don F. de T. : No. ¿ Dónde está la taquilla[1] ?

Mozo : Allá enfrente. ¿ Va Vd. en primera o en tercera ?

Don F. de T. : En tercera.

Mozo : La de tercera está detrás.

Don F. de T. : Bien. Entonces, si Vd. me lleva estas coasa al tren, le veré luego allí. Cójame Vd. un asiento de ventanilla, en un fumador, cara a la máquina si es posible.

Mozo : Muy bien, señor. El tren ha entrado en el andén Número 3.

Don F. de T. : Tenga Vd. cuidado con ese paquete, porque contiene cristal.

Mozo : Sí señor. No lo perderé de vista.

Don F. de T. (*al empleado de la taquilla*[1]). Un billete de ida y vuelta, de final de semana, para Birmingham, por favor (*or :* Birmingham, ida y vuelta ; hágame el favor).

Taquillero : Dieciocho chelines con nueve peniques.

Don F. de T. ¿ Cuánto se ahorra uno comprando este billete en vez del ordinario ?

Taquillero : Nueve chelines y un penique. El precio del billete de ida y vuelta, de final de semana, es, aproximadamente, el de un viaje y un tercio. Pero hay que volver por el tren del martes por la noche a más tardar.

Don F. de T. Perfectamente. ¿ Quiere Vd. darme cambio de un billete de cinco libras ?

Taquillero. Sí, señor. Pero tendrá Vd. que firmarlo en el reverso.

Don F. de T. : Con mucho gusto. ¿ Está cerca el quiosco de periódicos ?

Taquillero : A la izquierda, según sale Vd. de la taquilla.

Don F. de T. Ah, sí. (Va al quiosco.) ¿ Tiene Vd. el "Manchester Guardian" ?

Dependiente : No. Se han vendido todos esta mañana. Era un número especial de automovilismo.

Don F. de T. : ¿ Qué lástima ! Compraré el "Times." Deme Vd. también el "Radio Times." ¿ Cuánto es todo ?

Dependiente : Cuatro peniques, por favor. (*Después de tomar una moneda de plata de seis peniques.*) Aquí tiene Vd. dos peniques de cambio.

Don F. de T. Parece que no tiene Vd. un buen surtido de libros aquí.

Dependiente. Eso es cuestion del gerente, caballero.

Don F. de T. Bueno. ¿ Tiene Vd. entonces una guía de ferrocarriles ?

Dependiente : Sí Sr. aquí la tiene Vd.

Don F. de T. Al fin tengo ahora todo.

Dependiente : ¡ Caballero ! ¿ Son estos sus guantes ?

Don F. de T. : Sí, son . mis guantes nuevos. ¡ Qué tonto ! Vd. es muy amable. (Va al tren.) Vd. es mi mozo, ¿ verdad ?

Mozo. Sí señor. Le he guardado su asiento aquí y todas sus cosas están bien. Su maleta está bajo el asiento y el paquete está ahí arriba. Detrás de él he puesto la caja.

Don F. de T. : Bueno. Tenga Vd. (Le da unas monedas.)

Mozo : Muchísimas gracias, caballero.

Don F. de T. ¿ Se puede comer en el tren ?

Mozo : Sí, en el primer coche. El empleado (que está) a la puerta le dará a Vd. un billete. Pero pasará por aquí luego.

Don F. de T. Entonces atenderé a ello cuando venga. (*Ocupa su asiento.*)

Una Señora enfrente : Veo por la etiqueta de su maleta que viene Vd. de Berlín. Yo estuve en Berlín el año pasado y me divertí mucho allí.

Don F. de T. ¡ Ah ! ¿ Ha estado Vd. en Alemania ? ¡ Qué interesante ! ¿ Fué Vd. an aeroplano ?

Señora. Oh, no. Los aeroplanos no se han hecho para mí. Cada día publican los periódicos un nuevo accidente. En mi concepto el viajar por el aire no es, en manera alguna, seguro.

Don F. de T. : En Alemania, en estos días, todo el que tiene dinero va por aeroplano si tiene que hacer un viaje largo. En este país, las distancias son tan cortas, que no hay la misma necesidad de desarrollo aéreo.

Señora : No ; y por mi parte, no lo siento. No tengo el menor deseo de romperme el espinazo. ¿ Qué se gana con llegar a todas partes tan deprisa ? ¿ No son los trenes bastante veloces ? (espinazo = spine).

Don F. de T. (*sonriendo*) : Si Vd. fuera un hombre de negocios, señora, tendría Vd. otra idea del valor del tiempo. Ah ! ya estamos en marcha. ¿ Quiere Vd. que cierre la ventanilla ?

Señora : No, señor ; gracias. (Aspirando bocanadas de humo.) Los periódicos dicen que el aire evita resfriados.

Don F. de T. : ¡ Qué idea tan rara !

[1]taquilla = booking office. taquillero = booking office clerk

LESSON 9

The Essential Vocabulary—Nouns

In order to express more than 90 per cent of the ideas of everyday life, less than 1,000 words which differ in Spanish and English have to be mastered. In this Course the Vocabulary consists of 475 nouns similar in both languages and 450 dissimilar; 235 similar verbs and 280 dissimilar; 160 similar adjectives and 125 dissimilar. To these are added 180 invariable words (adverbs, prepositions, etc.). With the inflexions in the grammar and the system of word building given in Lesson 8, this will give a working vocabulary of several thousand words, which will not only enable the student to express himself fluently and seldom be at a loss, but also to read fairly advanced literature. The Spanish vocabulary is rich; but, for the English student, it is not difficult.

The similar words can be mastered in an hour or so; the work of learning them is not onerous.. When they have been mastered the dissimilar words will quickly be memorised. It has been ascertained that a beginner can learn 10–30 new words of a foreign language in an hour. After a few hours' practice 40–50 new Spanish words can be memorised every hour by an average student. Thus a good working vocabulary can be assimilated in less than a month. To have a vocabulary consisting of essential words that are *well known* is more than half the battle.

Many thousands of nouns are the same in Spanish and English, or almost identical in sound or spelling. They can be recognized in reading or when heard. Only those considered to be essential are given here, and they are given because they must be learnt. For it is of the utmost importance that the Spanish words necessary to express the most frequently recurring ideas should be on the tip of the tongue. It is one thing to recognize **El banco,** as the equivalent of "*the bank*"; but it is quite another thing to be able to think of **banco** when the idea of "*bank*" has to be expressed or is required. They are arranged in three Sections.

1. Nouns which are alike or almost alike in Spanish and English.
2. Nouns which differ.
3. Days of the week, months, and seasons.
4. Proper names.

Before proceeding to Section 2, the list of similar nouns should be mastered. Then Section 2 will be found to be easier. And so on.

As each word is being memorised an image of the thing or an association of the idea should be in the mind. This not only makes the learning process more interesting, and therefore easier, but it accustoms the learner to think in Spanish. Thus, when **El río** is being memorised think of a sparkling river, and imagine that you are bathing in it on a summer's day, and so on through the lists.

Know all the words BOTH WAYS: El hombre, *the man* — *the man,* **el hombre. Know them by SIGHT and by SOUND: and to pronounce without hesitation.**

NOTE. It will be noticed that in these lists the words are not in exact alphabetical order—purposely, to make the learning process more sure.

Section NOUNS SIMILAR IN FORM OR USAGE IN SPANISH AND ENGLISH

El automóvil, *motor-car*
El adorno, *ornament*
El azúcar, *sugar*
El accidente, *accident*
El agente, *agent*
El aire, *air*
El ángulo, *angle*
El animal, *animal*
El aparato, *apparatus*
El apetito, *appetite*
El arco, *arch*
El argumento, *argument*
El arte, *art* **(Las artes)**
El artículo, *article*
El autor, *author*
El aniversario, *anniversary*
El ácido, *acid*

La ambición, *ambition*
La arena, *arena, sand*
La ausencia, *absence*
La acción, *action*
La adición, *addition*
La aplicación, *application*
La asociación, *association*
La atracción, *attraction*
La autoridad, *authority*
La avenida, *avenue*
La asamblea, *assembly*
La armonía, *harmony*

El banco, *bank, bench*
El banquete, *banquet, feast*
El barril, *barrel, cask*
El beneficio, *benefit*
El botón, *button*

La base, *basis*
La batalla, *battle*
La bahía, *bay*
La bola, *ball*
La bota, *boot*
La botella, *bottle*
La bravura, *bravery*
La bondad, *bounty goodness*

El caso, *case, occurrence*
El comercio, *commerce*
El crimen, *crime*
El corriente, *current* (also **La** —)
El carbón, *carbon, coal*
El café, *café, coffee*
El colegio, *college*
El color, *colour*
El compañero, *companion*
El cerebro, *cerebrum, brain*
El carro, *cart, wagon, carriage*
El camarada, *comrade*
El capitán, *captain*
El campo, *camp, field, country*
El congreso, *congress*
El centro, *centre* (also *club*)
El capítulo, *chapter*
El cónsul, *consul*
El carácter, *character*
El contrato, *contract*
El cristiano, *Christian*
El cigarrillo, *cigarette*
El cigarro, *cigar* (often used for *cigarette*)
El consejo, *advice, council*
El condado, *county*
El club, *club*
El cañón, *cannon, gun; gorge (canyon)*
El crédito, *credit*
El cero, *zero*
El coche, *coach, cab, car*
El cobre, *copper*
El corcho, *cork*
El coraje, *courage*
El cheque, *cheque*
El choque, *shock, crash*
El coste, *cost*

La corte, *court, courtship*
La crema, *cream*
La criatura, *creature, baby*
La ciencia, *science*
La cruz, *cross*
La corona, *crown*
La cortina, *curtain*
La costumbre, *custom*
La carga, *charge, cargo load*
La costa, *coast*
La colección, *collection*
La conducta, *conduct*
La columna, *column*

Section 1. NOUNS SIMILAR IN FORM OR USAGE IN SPANISH AND ENGLISH (*contd.*)

La combinación, *combination*
La comisión, *commission, trust*
La compañía, *company*
La comparación, *comparison*
La carta, *card, letter*
La condición, *condition*
La capacidad, *capacity*
La confianza, *confidence*
La cámara, *room*
La conexión, *connexion, conjunction*
La causa, *cause*
La consecuencia, *consequence*
La consideración, *consideration*
La construcción, *construction*
La conversación, *conversation*
La cuerda, *cord, string*
La circunstancia, *circumstance*
La clase, *class*
La calidad, *quality*
La cantidad, *quantity*
La cuestión, *question*
La carrera, *career, course race*
La camisa, *chemise, shirt*
La chaqueta, *jacket, coat*

El departamento, *department*
El descubrimiento, *discovery*
El diablo, *devil*
El disgusto, *disgust*
El distrito, *district*
El día, *day*
El dolor, *pain*
El disturbio, *disturbance, interruption*
El detalle, *detail*
El deseo, *desire*
El doctor, *doctor*
El director, *director, manager*

La dama, *lady, gentlewoman*
La declaración, *declaration*
La defensa, *defence*
La demanda, *demand, claim*
La decisión, *decision*
La descripción, *description*
La destrucción, *destruction*
La diferencia, *difference*
La deuda, *debt*
La dificultad, *difficulty*
La digestión, *digestion*
La dirección, *direction*
La discusión, *discussion*
La distancia, *distance*
La distribución, *distribution*
La división, *division*
La duda, *doubt*

El equilibrio, *balance*
El escritorio, *desk*
El Este, *the East*
El efecto, *effect*
El esfuerzo, *effort*
El elástico, *elastic*
El enemigo, *enemy*
El estado, *state*
El extremo, *extreme*
El ejemplo, *example*
El embarque, *loading, embarkation*
El espacio, *space*
El espíritu, *spirit, ghost*
El estómago, *stomach*
El estudiante, *student*
El examen, *examination*
El exterior, *exterior*
El estilo, *style*
El edificio, *building, edifice*
El empleado, *employee*
El ejercicio, *exercise*
El estipendio, *stipend, salary*

La existencia, *existence*
La experiencia, *experience*
La enfermedad, *infirmity, illness*
La educación, *education*
La elección, *election*
La envidia, *envy*
La equivocación, *mistake*
La excepción, *exception*
La entrada, *entrance*
La extensión, *extension*
La escuela, *school*
La esponja, *sponge*
La estación, *season, station*
La estufa, *stove*
La estructura, *structure*
La esposa, *wife*
La especie, *species, kind*
La escena, *scene*

El fondo, *fund* (also *depth, bottom*)
El favorito, *favourite*
El frente, *front*
El futuro, *future* (also Lo —)
El funcionario, *official*
El favor, *favour*

La fe, *faith*
La familia, *family*
La fábula, *fable*
La fiebre, *fever*
La ficción, *fiction*
La figura, *figure, face*
La flor, *flower*
La forma, *form*
La fortuna, *fortune*
La fundación, *foundation*
La fuente, *fount, fountain*
La fruta, *fruit*
La felicidad, *happiness*
La fiesta, *feast* (**día de fiesta**, *holiday*)
La fabricación, *making, construction*
La frase, *sentence*
La fuerza, *strength*

El gas, *gas*
El general, *general*
El gobierno, *government*
El gobernador, *governor*
El grado, *grade*
El gato, *cat*
El grano, *grain*
El guía, *guide* (*man*)
El grupo, *group*

La gracia, *grace*
Las gracias, *thanks*
La guía, *guide* (*book*)
La gloria, *glory*

El héroe, *hero*
El hospital, *hospital*
El hotel, *hotel*
El humor, *humour*

La heroína, *heroine*
La historia, *history, st*
La honra, *honour*
La hora, *hour*

El impulso, *impulse*
El individuo, *individual*
El insecto, *insect*
El instrumento, *instrument*
El idioma, *idiom, language*
El intento, *intent, purpose*
El itinerario, *itinerary*
El impuesto, *duty, tax*
El importe, *amount, total, value*
El interés, *interest*

La idea, *idea*
La importancia, *importance*
La impresión, *impression*
La industria, *industry*
La influencia, *influence*
La información, *information, news*
La instrucción, *instruction, education*
La intención, *intention, design*
La isla, *island*
La inclinación, *inclination*
La inteligencia, *intelligence*

El jefe, *chief, head*

La justicia, *justice*

El limón, *lemon*
El límite, *limit*
El labio, *lip*
El líquido, *liquid*

La libertad, *liberty*
La ley, *law*
La lección, *lesson*
La luz, *light*
La línea, *line*
La lista, *list*

El médio, *half, middle*
El montón, *heap, pile*
El mercado, *market*
El matrimonio, *marriage*
El material, *material*
El miembro, *member*
El mercante, *merchant*
El mérito, *merit*
El método, *method*
El mediodía, *midday*
El millón, *million*
El modo, *mode, manner*
El mapa, *map*
El ministro, *minister*
El minuto, *the minute*
El modelo, *model*
El momento, *moment*
El movimiento, *movement*
El músculo, *muscle*
El maestro, *master*
El médico, *medical doctor*
El metal, *metal*
La máquina, *machine*
La mayoridad, La mayoría, *majority, superiority*
La manera, *manner*
La marca, *mark*
La masa, *mass*
La materia, *matter*
La medicina, *medicine*
La memoria, *memory*
La medianoche, *midnight*
La milla, *mile*
La mente, *mind*
La madre, *mother*
La montaña, *mountain*
La multiplicación, *multiplication*
La música, *music*
La marina, *sea-coast, marine*
La moda, *fashion*

El nervio, *nerve*
El número, *number* (*in order*)
El negocio, *affair, occupation*
Los negocios, *business matters*
El Norte, *North*
El nudo, *knot*

La Navidad, *Christmas*
La nación, *nation*
La necesidad, *necessity*
La noche, *night*
La nariz, *nose*
La nota, *note*
La noticia, *notice, knowledge*
Las noticias, *news, tidings*
La nuez, *nut*

El objeto, *object*
El océano, *ocean*
El oficial, *officer*
El óleo, *oil*
El odio, *odium, hate*
El Oeste, *the West*
El origen, *origin*

La orquesta, *orchestra*
La obligación, *obligation*
La oficina, *office*
La ocasión, *occasion, opportunity*
La operación, *operation*
La oportunidad, *opportunity*
La orden, *order*
La organización, *organization*
La oración, *prayer*
La observación, *observation*

El precio, *price*
El par, *pair*
El pariente, *relation* (**Los padres**, *parents*)
El placer, *pleasure*
El pasaje, *passage, fare*
El patrón, *patron, landlord, boss*
El paquete, *parcel*
El papel, *paper*
El paralelo, *parallel*
El perdón, *pardon*
El parque, *park*
El pasado, *past* (also Lo —)
El período, *period*

Section 1. NOUNS SIMILAR IN FORM OR USAGE IN SPANISH AND ENGLISH (*contd.*)

El piano, *piano*
El pastel, *pastry, pie*
El proyecto, *project*
El poema, *poem*
El poeta, *poet*
El portero, *porter, doorkeeper*
El presidente, *president*
El principal, *principal, chief*
El problema, *problem*
El producto, *product*
El profesor, *professor, teacher*
El progreso, *progress*
El público, *public*
El paso, *pace, step*

La preferencia, *preference*
La página, *page*
La paciencia, *patience*
La peseta, *peseta*
La pluma, *pen, plume*
La población, *population*
La persona, *person*
La planta, *plant*
La punta, *point, end* (also **el punto**)
La policía, *police, policeman*
La porción, *portion*
La posición, *position*
La posesión, *possession*
La práctica, *practice*
La provincia, *province*
La patata, *potato* (Spanish America, **La papa**)
La preparación, *preparation*
La presencia, *presence*
La prueba, *proof*
La propiedad, *property*
La proporción, *proportion*
La prosa, *prose*
La probabilidad, *probability*
La protección, *protection*
La parte, *part*

El químico, *chemist*
El queso, *cheese*

La química, *chemistry*

El renombre, *renown*
El recibo, *receipt*
El registro, *register*
El representante, *representative*
El ritmo, *rhythm*
El recreo, *recreation*

La raza, *race (of men)*
La razón, *reason*
La reacción, *reaction*
La religión, *religion*
La renta, *rent, income*
La revista, *review*
La regla, *rule*
La rosa, *rose*
La república, *republic*

El saco, *sack, bag*
El semblante, *aspect, look, appearance*
El suelo, *ground, soil*
El sistema, *system*
El salón, *drawing-room, saloon*
El sacrificio, *sacrifice*
El secreto, *secret*
El secretario, *secretary*
El sentido, *sense, feeling, meaning*
El servicio, *service*
El sexo, *sex*
El silencio, *silence*
El soldado, *soldier*
El sonido, *sound*
El sitio, *site, place*
El sujeto, *subject*
El substituto, *substitute*
El Sur, Sud, *south*
El santo, *saint*
El socorro, *help*

La seguridad, *security, safety*
La satisfacción, *satisfaction*
La sazón, *seasoning, flavour*
La sección, *section*
La situación, *situation*
La sociedad, *society*
La sopa, *soup*
La substancia, *substance*
La suma, *sum*
La superficie, *surface*
La simpatía, *sympathy*
La sospecha, *suspicion*

El testimonio, *testimony*
El tubo, *tube*
El terreno, *ground, field of action*
El té, *tea*
El telégrafo, *telegraph*
El telegrama, *telegram*
El teléfono, *telephone*
El templo, *temple*
El término, *end, ending*
El territorio, *territory*
El teatro, *theatre*
El tiempo, *time, weather*
El título, *title*
El total, *total*
El tratamiento, *treatment, usage*
El tren, *train*
El tipo, *type*
El tribunal, *tribunal, law court*

La tabla, *board, shelf, tray*
La tempestad, *storm*
La teoría, *theory*
La tonelada, *ton*
La tranquilidad, *quietness*

El último, *last, final*
El uso, *use*

La unión, *union*
La unidad, *unity*
La universidad, *university*

El vapor, *steam, steamer*
El vagón, *wagon, car*
El vestido, *garment*
El volumen, *volume*
El voto, *vote*
El valle, *valley*
El vino, *wine*
El verso, *verse*

La vista, *sight*
La vecindad, *vicinity*
La vacación, *vacation*
La vibración, *vibration*
La variedad, *variety*
La virtud, *virtue*
La violeta, *violet*
La visita, *visit*

Section 2. NOUNS WHICH DIFFER IN THE TWO LANGUAGES

El almuerzo, *breakfast*
El amo, *master*
El aceite, *olive oil*
El alfiler, *pin*
El asado, *roast*
El alumno, *pupil*
El arroz, *rice*
El anillo, *ring*
El asiento, *seat*
El acero, *steel*
El almacén, *store, shop*
El arroyo, *brook*
El árbol, *tree*
El año, *year*
El asunto, *event*
El algodón, *cotton*
El aliento, *breath, spirit*
El acontecimiento, *incident*
El amigo, *friend*
El aposento, *room, apartment*
El amor, *love*
El amante, *lover*
El agua (f.), *water*
El ala (f.), *wing*
El alma (f.), *soul*

La araña, *spider*
La aldea, *village, town*
La alegría, *joy, mirth*
La aduana, *customs house*
La ayuda, *help*
La abeja, *bee*
La avena, *oats*
La almohada, *pillow*
La amistad, *friendship*
La altura, *height*
La aguja, *needle*

El brazo, *arm*
El balde, *bucket*
El baile, *dance*
El bolsillo, *pocket*
El bastón, *stick*
El buque, *boat, ship*
El billete, *ticket* (Spanish America, **boleto**)
El beso, *kiss*
El baúl, *trunk, box*
El bosquejo, *sketch summary*
El barro, *clay, mud*

La belleza, *beauty*
La baya, *berry*
La barba, *beard*
La bebida, *drink*
La bolsa, *the purse* (also *Stock Exchange*)
La bandera, *flag, banner*
La burla, *jest, joke*
La biblioteca, *library*
La boca, *mouth*
La bomba, *pump*
La bienvenida, *welcome*

El cuello, *collar, neck*
El cuidado, *care*
El cesto, *basket*
El cinto, *girdle, belt*
El cuerpo, *body*
El carnicero, *butcher*
El cuarto, *the quarter* (also *room*)
El cocinero, *cook*
El ciudadano, *citizen*
El calor, *heat*
El concurso, *crowd*
El cambio, *change*
El caballero, *gentleman, horseman*
El crecimiento, *increase, growth*
El conocimiento, *knowledge*
El convenio, *agreement, contract*
El corazón, *heart*
El cielo, *sky, heaven*
El collado, *hill, hillock*
El cerdo, *pig, pork*
El caballo, *horse*
El cuerno, *horn*
El convite, *invitation*
El cuchillo, *knife*
El criado, *servant*
El correo, *post*
El clavo, *nail*
El cuadro, *picture, frame*
El cochino, *pig*
El catedrático, *professor (University)*
El comedor, *dining-car, -room*
El camino, *road, route*
El caucho, *indiarubber*
El carnero, *mutton, sheep*
El casco, *shell*
El calcetín, *sock*
El caldo, *thick soup*
El cordón, *cord, string*
El chasco, *joke, trick*
El cumpleaños, *birthday*

La campana, *bell*
La caja, *case, box, safe*
La carne, *meat, flesh*
La cadena, *chain, fetter*
La cocina, *kitchen*
La ciudad, *city*
La corrida, *course*
La corrida de toros, *bull-fight*
La cosecha, *harvest*
La comida, *dinner, food*
La cara, *face, visage*
La cabra, *goat*
La cabeza, *head*
La casa, *house*
La caza, *hunt*
La caldera, *boiler, kettle*
La cerradura, *lock*
La cárcel, *barracks, gaol*
La cinta, *ribbon, tape*
La culebra, *snake*

Section 2. NOUNS WHICH DIFFER IN THE TWO LANGUAGES (*contd.*)

La canción, *song*
La cama, *bed*
La cuchara, *spoon*
La calle, *street*
La cena, *supper*
La cuenta, *account*
La cosa, *thing*
La cima, *summit top*
La cera, *wax*

El desayuno, *breakfast*
El dinero, *money*
El delito, *wrong, delinquency*
El daño, *damage*
El desarrollo, *development, evolution*
El dedo, *finger*
El dedo de pie, *toe*
Dios, *God*
El derecho, *right* (also *law*)
El despacho, *office*
El dueño, *owner*
El deber, *duty*
Don, *Mr., sir*
Doña, *Mrs.*
El diente, *tooth*

El ejército, *army*
El enlace, *link, lacing*
El ente, *entity, being*
El escogimiento, *selection, choice*
El estanciero (Spanish America), *farmer*
El extranjero, *stranger, foreigner*
El escritor, *writer*

La escoba, *broom, brush*
La esquina, *corner*
La entrega, *delivery*
La estancia, Spanish, *stay, sojourn*, Spanish America, *farm*
La esperanza, *hope*
La escala, *scale*
La escalera, *ladder, stairs*
La estrella, *star*
La edad, *age*

El freno, *brake*
El filo, *edge (of knife, etc.)*
El fin, *end*
El fuego, *fire*
El fósforo, *match*
El ferrocarril, *railway*

La fábrica, *factory* (also *manufacture*)
La fecha, *date*
La falta, *fault, error* (also *lack*)
La firma, *signature*

El golpe, *blow*
El ganado, *cattle*
El gasto, *expense* (also *waste*)
El guante, *glove*
El gancho, *hook*
Los géneros, *goods, merchandise*
El gusto, *taste, pleasure*
El gerente, *manager*

La gorra, *cap*
La greda, *chalk*
La gota, *drop*

La gallina, *hen*
La gente, *people*
La garganta, *throat*
La guerra, *war*
La gana, *desire, appetite*

El hambre (f.), *hunger* (**Tener hambre**, *to be hungry*)
El hueso, *bone*
El hermano, *brother*
El hijo, *son*
El hecho, *act, deed*
El huevo, *egg*
El huésped, *guest*
El heno, *hay*
El hogar, *hearth, home*
El hielo, *ice, frost*
El hierro, *iron*
El hombre, *man*
El horno, *oven, furnace*
El hombro, *shoulder*
El hilo, *thread, wire*
El habla (f.), *speech, language*

La hormiga, *ant*
La hermosura, *beauty*
La hoia, *leaf*
La hacienda, *landed estate* (also *the Treasury*)
La hechura, *form, cut, workmanship*
La hierba, *grass*
La herramienta, *tool*
La hembra, *female*

El invierno, *winter*

La iglesia, *church*

El lápiz, *pencil*
El libro, *book*
El latón, *brass*
El ladrillo, *brick*
El lugar, *place*
El látigo, *whip*
El loco, *madman, fool*
El lado, *side*

La leche, *milk*
La lona, *canvas*
La lima, *file* (also *lime-tree*)
La lámpara, *lamp*
La luna, *moon*
La lástima, *pity*
La libra, *pound*
La lágrima, *tear*
La lengua, *tongue, language*
La lana, *wool*

El llano, *plain, flat (surface)*

La llegada, *arrival*
La llama, *flame, light*
La lluvia, *rain*
La llave, *key*

El manzano, *apple tree*
El mensaje, *message*
El miedo, *fear*
El muchacho, *boy*
El martillo, *hammer*
El marido, *husband*
El macho, *male*
El mozo, *boy, waiter*
El molino, *mill*
El mono, *monkey*

El mes, *month*
El melocotón, *peach*
El montón, *heap, pile*
El mundo, *world*
Los muebles, *furniture*

La manzana, *apple*
La manteca, *lard, butter*
La mantequilla (Spanish America), *butter*
La mudanza, *change*
La muerte, *death*
La muestra, *sample*
La mitad, *half*
La mano, *hand*
La miel, *honey*
La medida, *measure, measurement*
La malla, *mesh*
La mañana, *morrow, morning*
La marmita, *kettle, pot*
La mar, *sea*
La media, *stocking* (Spanish America)
La mesa, *table*
La mujer, *woman*
La madera, *wood*
La mentira, *lie, untruth*

El niño, *child*
El nacimiento, *birth*
El nombre, *name, number*

La niebla, *fog, mist*
La naranja, *orange*
La nieve, *snow*

El ojo, *eye*
El oro, *gold*
El otoño, *autumn*

La oreja, *ear*
La onda, *wave, billow*
La obra, *work, achievement*

El pajaro, *bird*
El pan, *bread*
El paño, *cloth*
El peine, *comb*
El pais, *country*
El primo, *cousin*
El paraguas, *umbrella*
El peligro, *peril, danger*
El perro, *dog*
El peso, *weight, dollar*
El polvo, *dust*
El plato, *plate, dish*
El perito, *expert*
El padre, *father*
El pescado, *fish*
El puente, *bridge*
El piso, *floor, storey (of a house)*
El pie, *foot*
El pollo, *fowl, cock*
El porvenir, *future* (also **Lo** --)
El pelo, *hair*
El pañuelo, *handkerchief*
El puño, *fist*
El puerto, *port*
El puerco, *pig, pork*
El puntapié, *kick*
El plomo, *lead*
El pulmón, *lung*
El partido, *party* (also *game*)

El poder, *power*
El paciente, *patient*
El pago, *payment*
El pedazo, *piece, slice*
El palo, *stick, timber, mast*
El premio, *prize*
El provecho, *benefit*
El Papa, *Pope* (in Spanish America **La papa** is *potato*)
El pensamiento, *thought*
El pulgar, *thumb*
El pueblo, *people, nation, village*
El promedio, *average*
El principio, *beginning*

Los pantalones, *trousers*
Los postres, *dessert*

La playa, *shore, beach*
La plaza, *square, place*
La pregunta, *request*
La puerta, *door*
La plata, *silver* (Spanish America, used for *money*)
La piel, *skin, hide*
La prisa, *hurry, urgency*
La posada, *inn, small hotel*
La pulgada, *inch*
La pierna, *leg*
La propuesta, *offer, tender*
La pasta, *paste*
La paz, *peace*
La prenda, *pledge*
La prensa, *press*
La pena, *penalty, trouble, grief*
La peña, *rock*
La primavera, *spring*
La piedra, *stone*
La propina, *present, gratuity, tip*
La pared, *wall*
La palabra, *word*
La pérdida, *loss*
La proposición, *proposal, proposition*

El quitasol, *parasol*

El reloj, *watch, clock*
El rincón, *corner*
El rancho, *food, mess* (also *ranch*)
El rey, *king*
El retrato, *portrait*
El rato, *a short period, moment*
El ratón, *mouse*
El rayo, *ray* (of *light*, etc.)
El ruego, *request*
El rio, *river*
El regalo, *present*
El ruido, *noise*

La respuesta, *reply*
La ribera, *bank (of a river)*
La rama, *shoot, sprig; raw material*
La rodilla, *knee*
La ropa, *cloth*
La rueda, *wheel*
La red, *net, grating*
Las ropas, *clothes*
La raiz, *root*

Section 2. NOUNS WHICH DIFFER IN THE TWO LANGUAGES (*contd.*)

El ser, *being*
El seso, *brain*
El suceso, *event*
El siglo, *century*
El sacacorchos, *corkscrew*
El sueño, *sleep, dream*
El Señor, *the lord, gentleman*
Señor, *Mr., sir*
Señorito, *young man Master*
El sombrero, *hat*
El seguro, *insurance*
El sueldo, *salary*
El sello, *stamp, seal*
El sol, *sun*
El sobre, *envelope*

La sartén, *frying pan*
La señal, *sign*
La sangre, *blood*
La silla, *armchair*
La suerte, *luck, chance*
La selva, *wood*
Señora, *lady, Mrs.*
Señorita, *young lady, Miss*
La sala, *hall*
La salud, *health*
La salida, *exit*
La senda, *footpath*
La sal, *salt*
La sombra, *shadow*
La seda, *silk*
La salvilla, *salver, tray*
La semana, *week*
La sabiduría, *wisdom*
La sed, *thirst*
(**Tener sed,** *to be thirsty*)

El toro, *bull*
El trigo, *wheat*
El traje, *dress*
El tenedor, *fork*
El trapo, *rag, tatter*
El techo, *roof*
El trueno, *thunder*
El tornillo, *screw*
El tamaño, *size, shape, bulk, dimension*
El tío, *uncle*
El trabajo, *work, labour*

La torta, *tart*
La tortilla de huevos *omelette*
La taza, *cup*
La tierra, *land, earth*
La tarde, *evening*
La tinta, *ink*
La tienda, *shop, store*
La tristeza, *sadness*
La tarea, *task*
La tos, *cough*
Las tijeras, *scissors*

El vidrio, *window, glass*
El vaso, *glass, tumbler*
El viaje, *voyage*
El varón, *man, male*
El vecino, *neighbour*
El veneno, *poison*
El verano, *summer*
El valor, *value*
El vuelo, *flight*
El viento, *wind*
El viudo, *widower*

La vasija, *vessel, cask*
La vaca, *cow*
La vida, *life*
La vela, *sail*
La venta, *sale*
La vergüenza, *shame*
La vía, *way, road, route*
La vuelta, *turn, return*
La verdad, *truth*
La voz, *voice*
La ventana, *window*
La ventaja, *advantage*
La vez, *occasion, time*

El zapato, *shoe*
El zapatero, *shoemaker*

Section 3. DAYS OF THE WEEK, MONTHS, SEASONS

Days of the Week

Lunes, *Monday*
Martes, *Tuesday*
Miércoles, *Wednesday*
Jueves, *Thursday*
Viernes, *Friday*
Sábado, *Saturday*
Domingo, *Sunday*

Seasons

La primavera, *spring*
El verano, *summer*
El otoño, *autumn*
El invierno, *winter*

Months of the Year

Enero, *January*
Febrero, *February*
Marzo, *March*
Abril, *April*
Mayo, *May*
Junio, *June*
Julio, *July*
Agosto, *August*
Setiembre, *September* (also **Septiembre**)
Octubre, *October*
Noviembre, *November*
Diciembre, *December*

Section 4. PROPER NAMES

Inglaterra, *England*
Un inglés, *an Englishman*
La Gran Bretaña, *Great Britain*
El Reino Unido, *The United Kingdom*
España, español : *Spain Spaniard*
Francia, francés : *France Frenchman*
Italia, italiano : *Italy Italian*
Alemania, alemán : *Germany, German*
Portugal, portugués : *Portugal, Portuguese*
Rusia, ruso : *Russia, Russian*
Los Estados Unidos, *The United States*
Un Norteamericano : *An American* (i.e. from the U.S. **Un americano** usually means a Central or South American)
El Brasil, un Brasileño, *Brazil, a Brazilian*
El Perú, un Peruano
Méjico, Mejicano
Chile, Chileno
La Argentina, un Argentino
El Uruguay, Uruguayo, *Uruguayan* (also called *Oriental* in the River Plate, because Uruguay is **La República Oriental del Uruguay**)
Panamá, Panameño
Venezuela, Venezolano
Guatemala, Guatemalteco
South America is either **Sud América** or **América del Sur.**
See also p. 2207.

The student is advised to take a little care with Spanish proper names, as they often vary in an unexpected manner. The foreigner is tempted to write or say "Galiciano," "Andaluciano" for natives of the Spanish provinces of Galicia and Andalucia whereas the correct forms are **Gallego, Andaluz.** Similarly **Catalán** is a Catalonian.

NOTE.—**Madrileño, Malagueño, Sevillano, Gaditano** : native of Madrid, Málaga, Seville, Cadiz.

In Spanish America an Englishman is colloquially (and sometimes contemptuously) **Un gringo.** A North American is **Un Yanqui.** A Chilean wishing to say that So-and-so is a countryman will say "**Es Chilenito**" the diminutive being used as a term of approval. Similarly, **un gringuito** is a pleasing term for an Englishman, and **Cholo** (a Peruvian Indian) changed to **Cholito** is used for Peruvian generally (and affectionately), etc. An Argentine wishing to say that So-and-so is a native of Buenos Aires will say "**Es porteño**" (i.e. *from the port*). It will be appreciated from the few examples given that there are pitfalls in Spanish proper names. If warning is taken at the outset, they will quickly be overcome.

LESSON 10

Essential Vocabulary—Verbs, Adjectives, and Invariable Words

Many Spanish verbs resemble their English equivalents but for the grammatical endings peculiar to Spanish. The lists which follow should be mastered and, to begin with, each verb conjugated in accordance with the rules and table given in p. 2214.

Section 1. VERBS SIMILAR IN FORM OR USAGE IN SPANISH AND ENGLISH

ENDING IN -AR

aceptar, *to accept*
acostumbrar, *to accustom*
acomodar, *to accommodate, adjust*
admirar, *to admire, wonder at*
adoptar, *to adopt*
avisar, *to advise, notify*
apelar, *to appeal*
aplicar, *to apply*
apreciar, *to appreciate*
aprobar, *to approve*
asociar, *to associate*
asegurar, *to assure*
atacar, *to attack*
agitar, *to shake, agitate*
ajustar, *to adjust, trim*
acompañar, *to accompany*
aumentar, *to augment increase*
abandonar, *to abandon*
afirmar, *to affirm*
anunciar, *to announce, advertise*

comenzar, *to commence*
cesar, *to cease*
celebrar, *to celebrate*
cargar, *to charge, load*
comparar, *to compare*
confirmar, *to confirm*
considerar, *to consider*
consultar, *to consult*
contestar, *to contest* (also *to reply*)
continuar, *to continue*
copiar, *to copy*
contar, *to count, relate*
crear, *to create, bring up*
cultivar, *to cultivate*
consolar, *to console, relieve*
confiar, *to confide, trust*
calcular, *to calculate*
causar, *to cause*
conservar, *to conserve*
confesar, *to confess*
contemplar, *to contemplate*
condenar, *to condemn*
certificar, *to register a letter, certify*
comunicar, *to communicate*
cortar, *to cut, shorten*
costar, *to cost*
conjeturar, *to conjecture, guess*
cruzar, *to cross*

doblar, *to double*
determinar, *to determine, decide*
declarar, *to declare*
depositar, *to deposit*
dedicar, *to dedicate*
desear, *to desire, wish, want*
durar, *to endure, last*
dominar, *to dominate*
demostrar, *to demonstrate*
dudar, *to doubt*

efectuar, *to effect, accomplish*
emplear, *to employ use*
entrar, *to enter*
escapar, *to escape*
examinar, *to examine*
excitar, *to excite*
explicar, *to explain*
expresar, *to express*
encontrar, *to encounter, meet*
ejecutar, *to execute, perform*
estimar, *to esteem, respect*
estimular, *to stimulate, urge*
errar, *to wander*
estudiar, *to study*
elevar, *to elevate, lift*

fundar, *to found*
forzar, *to force, compel*
formar, *to form*
figurar, *to figure fancy*

ganar, *to gain, win*
graduar, *to graduate*

honrar, *to honour*

inspirar, *to inspire*
ignorar, *to be ignorant of*
imaginar, *to imagine*
inclinar, *to incline*
indicar, *to indicate*
informar, *to inform*
informarse, *to get to know*
importar, *to be important (to matter)*
interesar, *to interest*

justificar, *to justify*

limitar, *to limit*
libertar, *to set at liberty*

marchar, *to march*
mencionar, *to mention*
multiplicar, *to multiply*
manifestar, *to manifest*

notar, *to note*
necesitar, *to necessitate, want*
nombrar, *to name, appoint*

ordenar, *to arrange, order, ordain*
observar, *to observe*
ocupar, *to occupy*
ocuparse, *to be busy with*
obligar, *to oblige compel*

progresar, *to progress*
perdonar, *to pardon, excuse*
pronunciar, *to pronounce*
publicar, *to publish*
probar, *to prove, test, try*
predominar, *to predominate, prevail*
preservar, *to preserve*
preparar, *to prepare*
pagar, *to pay*
pasar, *to pass*
presentar, *to present, introduce*
procurar, *to try to, to get*
penetrar, *to penetrate*

quitar, *to take away*
quitarse, *to take off (a garment)*

recobrar, *to recover*
rehusar, *to refuse*
registrar, *to register, enrol*
reparar, *to repair*
robar, *to rob*
recordar, *to remind, recall*
renovar, *to renew*
reservar, *to reserve*
resultar, *to result*
retirarse, *to retire*
representar, *to represent*

señalar, *to stamp, sign, signalize*
sonar, *to sound, ring*
separar, *to separate*

terminar, *to end*
trazar, *to trace*
temblar, *to tremble, quake*
transportar, *to transport*
telefonear, *to telephone*

usar, *to use, wear, to accustom*

visitar, *to visit*

ENDING IN -ER

atender, *to attend*
aparecer, *to appear*

contener, *to contain*
convencer, *to convince*
conceder, *to concede, grant*
comprender, *to understand, grasp*
corresponder, *to correspond*
cometer, *to commit, entrust*
detener, *to detain*
defender, *to defend*
depender (de), *to depend upon*
disponer, *to dispose*
desaparecer, *to disappear*

establecer, *to establish*
extender, *to extend*
entretener, *to entertain*
exponer, *to expose, expound*

favorecer, *to favour, protect*

haber, *to have (auxiliary)*
haber de, *to have to*

imponer, *to impose*

meter, *to place, put in*
mantener, *to maintain*
mover, *to move*

ofender, *to offend, injure*
obtener, *to obtain, get*
obedecer, *to obey*
ofrecer, *to offer*

prometer, *to promise*
proveer, *to provide, stock*
proponer, *to propose, determine*
proponerse, *to intend*
poseer, *to possess, own*
pretender, *to pretend*
proceder, *to proceed*

resolver, *to resolve, decide*
responder, *to respond, answer*
recorrer, *to run over, survey*

sostener, *to sustain*
sorprender, *to surprise*
someter, *to submit*
satisfacer, *to satisfy*

ENDING IN -IR

admitir, *to admit, to permit*
asistir, *to assist, be present at*
aplaudir, *o applaud, praise*

batir, *to beat, defeat*

convertir, *to convert*
concluir, *to conclude end*

Section 1 VERBS SIMILAR IN FORM OR USAGE IN SPANISH AND ENGLISH (*contd.*)

ENDING IN -IR (*contd.*)

construir, *to construct, build*
contradecir, *to contradict*
conducir, *to conduct, lead*
consistir, *to consist*
cubrir, *to cover*
comprimir, *to compress crush*
corregir, *to correct*
constituir, *to constitute*
confundir, *to confound*

divertir, *to amuse, divert*
decidir, *to decide*
desunir, *to separate, disunite*

destruir, *to destroy, spoil*
distinguir, *to distinguish*
descubrir, *to discover*

elegir, *to elect*
existir, *to exist*

garantir, *to guarantee*

interrumpir, *to interrupt*
incluir, *to enclose, include*
instruir, *to instruct, educate*
impedir, *to impede, prevent*
imprimir, *to print, impress*

occurrir, *to occur* (also, *to go to meet*)

prohibir, *to prohibit, forbid*
partir, *to part, divide, separate*
producir, *to produce*
presumir, *to presume*
preferir, *to prefer*
persuadir, *to persuade*
permitir, *to permit*

recibir, *to receive*
reducir, *to reduce*
repetir, *to repeat*

referir, *to refer, relate to*
reunir, *to reunite*

substituir, *to substitute*
sufrir, *to suffer*
servir, *to serve*
servirse, *to deign condescend*

transferir, *to transfer*
traducir, *to translate*

unir, *to unite*

vestir, *to clothe*
vestirse, *to dress oneself*

Section 2. VERBS WHICH ARE DISSIMILAR IN THE TWO LANGUAGES

ENDING IN -AR

adelantar, *to advance*
aconsejar, *to counsel, advise*
ayudar, *to help, aid*
acercarse, *to approach*
arreglar, *to arrange*
aguardar, *to await*
atar, *to attach to*
acordar, *to agree*
acordarse, *to remember, recollect*
acabar, *to end*
amueblar, *to furnish*
andar, *to go, walk*
alquilar, *to hire, rent*
amar, *to love*
alcanzar, *to reach, attain to*
alabar, *to praise, commend*
alegrarse, *to rejoice, be pleased*
asar, *to roast, toast*
almorzar, *to breakfast*
acertar, *to hit the mark, happen suddenly*
arrastrar, *to creep, crawl, drag*
ahogar, *to choke, drown*
apoyar, *to favour, patronize, abet*
arrancar, *to force out, extirpate*
abrazar, *to embrace, hug*
atravesar, *to pass over or through*
apartar, *to separate, divide, remove*
arrojar, *to fling, hurl* (also, *to sprout*)
aprovechar, *to progress, benefit by*
amenazar, *to threaten, menace*
asomar, *to become visible, loom* (also, *to be flustered*)

bastar, *to suffice*
brindar, *to drink one's health*
besar, *to kiss*
buscar, *to search, seek out*
bailar, *to dance*
bajar, *to lower, go down*

callar (se), *to be silent*
convidar, *to invite*
culpar, *to blame*
comprar, *to buy*
cavar, *to dig*
cobrar, *to recover, collect, gain*
cuidar, *to take care of*
cambiar, *to change, exchange*
colgar, *to hang*
colocar, *to place, locate*
casar, *to marry*
casarse, *to get married*
cansarse, *to get tired*
cansar, *to weary*
cantar, *to sing*
cerrar, *to shut, lock*
cortar, *to cut, shorten*
charlar, *to chatter*

despertar, *to startle awaken*
descansar, *to rest*
dejar, *to leave, let*
disculpar, *to excuse, pardon*
dar, *to give*
dibujar, *to draw, design, describe*
dañar, *to damage*
descuidar, *to neglect, ignore*
dispensar, *to excuse, exempt*

encerrar, *to lock or shut up*
evitar, *to avoid*
esperar, *to hope, expect, wait for*
empezar, *to begin*
empezar, *to begin*
entregar, *to deliver*
empujar, *to press, drive, compel*
empeñar, *to engage, pledge*
equivocarse, *to make a mistake*
espantar, *to astound, scare*
estornudar, *to sneeze*
enseñar, *to teach*
echar, *to throw*
engañar, *to deceive*
engañarse, *to err, mistake*
encantar, *to charm*
enviar, *to send*
escuchar, *to listen to*
estar, *to be (temporary state)*

estar de prisa, *to be in a hurry*
estar bien, *to be well*
extrañarse, *to be surprised at*
encaminarse, *to travel (a road)*
encargar, *to charge, commission*
enamorar, *to enamour* (—se, *to fall in love*)

faltar, *to be short of, to fail*
fijar, *to fix, set*
fijarse, *to pay attention to*
felicitar, *to congratulate*
fumar, *to smoke*

gritar, *to cry out*
gastar, *to spend, waste*
gustar, *to taste, give pleasure*
gustar de, *to like, enjoy*
guardar, *to retain* (also, *to beware of*)
gobernar, *to govern, control*
golpear, *to strike a blow*
gozar, *to enjoy, rejoice*

helar, *to freeze*
hablar, *to speak*
hallar, *to find*
hospedar, *to give hospitality to*

juntar, *to join*
juzgar, *to judge*
jugar, *to play (a game)*
jurar, *to swear*

limpiar, *to clean*
lavar, *to wash*
luchar, *to struggle, wrestle*
lograr, *to succeed*
levantar, *to lift*
levantarse, *to get up*
lanzar, *to fling* (also, *to let loose*)

llevar, *to bring, carry, wear*
llamar, *to call*
llamarse, *to be named*
llenar, *to fill*
llegar, *to arrive*
llorar, *to weep*

mojar, *to wet, dampen*
mostrar, *to show, demonstrate*
mudar, *to change, remove*
mezclar, *to mix*
manejar, *to manipulate, manage*
mirar, *to look at*
matar, *to kill*
mejorar, *to improve*
mandar, *to command, order*

negar, *to deny*
nadar, *to swim*
nevar, *to snow*

osar, *to dare*
olvidarse, *to forget*
orar, *to pray (to the Deity)*

prestar, *to lend*
pasearse, *to go for a walk*
pensar, *to think*
preguntar, *to ask, ask for*
pararse, *to stop, remain, delay*
predicar, *to preach, predict*
pelearse, *to fight, quarrel*
plegar, *to fold, double up, bend*
pegar, *to strike a blow*
pesar, *to weigh*
picar, *to pierce, sting, itch, pique*

quebrar, *to break, crack*
quemar, *to burn*
quejarse, *to complain*
quedarse, *to remain (behind)*

regalar, *to give a present*
regresar, *to return (home)*
resfriarse, *to catch a cold*
recompensar, *to reward*
revocar, *to recall*
reventar, *to burst*
rogar, *to pray, request politely*
rodear, *to go round encompass*

soplar, *to blow*
soñar, *to dream*
sanar, *to cure*
saludar, *to salute, greet*
salvar, *to save*
sentarse, *to sit down, be seated*

Section 2. VERBS WHICH ARE DISSIMILAR IN THE TWO LANGUAGES *(contd.)*

ENDING IN -AR *(contd.)*

sacar, *to take out of*
soltar, *to untie, loosen*

trabajar, *to work*
tardar, *to be late, grow late*
tratar, *to treat, deal*
tratar de, *to try to*
tirar, *to draw, pull, shoot*
tomar, *to take*

tocar, *to touch* (also, *to play a musical instrument*)
trepar, *to climb (a ladder, etc.)*
tronar, *to thunder*

viajar, *to travel*
volar, *to fly*

ENDING IN -ER

agradecer, *to thank*
aprender, *to learn*
abastecer, *to supply*
atreverse, *to dare*

beber, *to drink*

complacer, *to oblige*
coser, *to sew*
caer, *to fall, happen, decrease*
componer, *to compose, compound*
correr, *to run*
conocer, *to know, be acquainted with*
crecer, *to grow*
comer, *to eat*
cocer, *to boil, cook*
creer, *to believe*
coger, *to catch, pick up*
caber, *to be able to contain, to have room, place, to fit*

desenvolver, *to develop, to unfold*
deber, *to have a duty, must, to owe*
doler, *to ache*
deshacer, *to undo, destroy*

estremecerse, *to shake, tremble*

entender, *to hear, understand*
escoger, *to choose, select*
emprender, *to undertake*
encender, *to kindle, set fire to*

hacer, *to do, make, cause act*
hacer mal, *to hurt*
hender, *to crack*

leer, *to read*
llover, *to rain*

merecer, *to deserve, merit*
morder, *to bite*

nacer, *to be born*

poder, *to be able*
perder, *to lose*
parecer, *to seem, appear*
pertenecer, *to belong to*
poner, *to put*
permanecer, *to persist, last, remain*

querer, *to like, love, want*
querer decir, *to mean*

reconocer, *to recognize*

ENDING IN -ER *(contd.)*

romper, *to tear*
recoger, *to collect, pick up*
rendir, *to subject, conquer*

suponer, *to suppose*
ser, *to be (permanent state)*
ser menester, *to be necessary*
suceder, *to occur, happen*
soler, *to be wont*
saber, *to know (by learning)*

torcer, *to twist*
tener, *to hold, possess, keep*
traer, *to bring, draw*
temer, *to fear*
tender, *to stretch, extend*

volver, *to turn, return*
ver, *to see*
vender, *to sell*
valer, *to be worth*
vencer, *to conquer*

ENDING IN -IR

añadir, *to add*
abrir, *to open*
advertir, *to warn*
acudir, *to assist, support*
adquirir, *to acquire, obtain, get*

bendecir, *to bless*

convenir, *to agree, become, suit*
cumplir, *to fulfil*
conseguir, *to attain, get, obtain*

dormir, *to sleep*
dormirse, *to fall asleep*
dirigirse (a), *to refer to, apply to, to go towards*
decir, *to say, tell*
despedir, *to emit, discard* (also, *to take leave of* —se)

escribir, *to write*

fingir, *to act, pretend*

herir, *to wound*
huir, *to flee, escape*

ir, *to go somewhere*
irse, *to go away, out of*

lucir, *to shine*

morir, *to die*
mentir, *to tell a lie*

oir, *to hear*

proseguir, *to pursue*
pedir, *to beg, request*

reir, *to laugh*
reirse, *to laugh at*

sentir, *to feel* (also, *to feel sorry*)
seguir, *to follow*
sugerir, *to suggest*
salir, *to go out of, depart*
sonreir, *to smile*[1]

venir, *to come*
vivir, *to live*

[1] Note that throughout the above list of verbs, and in the language generally, compounds are conjugated like their "root" or original verbs . sonreír like reír- etc

VOCABULARY OF ESSENTIAL ADJECTIVES

Section 1. ADJECTIVES SIMILAR IN FORM OR USAGE IN SPANISH AND ENGLISH

ausente, *absent*
actual, *actual, present*
activo, *active*
agradable, *agreeable*
antiguo, *antique, old*
anual, *annual*
automático, *automatic*
afortunado, *fortunate, lucky*
amable, *amiable*
anterior, *anterior*
áspero, *rough*
admirable, *admirable*
agudo, *acute*
acostumbrado, *accustomed*
absoluto, *absolute*

blanco, *blank, white*

completo, *complete*
conciso, *concise*
claro, *clear, light in colour*
capaz, *capable*
central, *central*
cierto, *certain, sure*
circular, *circular*
civil, *civil*

continuo, *continual*
cómodo, *convenient*
comercial, *commercial*
común, *common*
complicado, *complicated*
consciente, *conscious*
contento, *content*
contrario, *contrary, opposite*
cruel, *cruel*
cómico, *comic*
culpable, *culpable, guilty*
curioso, *curious, strange*

diario, *daily*
diferente, *different*
distinto, *distinct*
doméstico, *domestic*
doble, *double*
delicioso, *delicious*
desconsolado, *disconsolate, sad*
delicado, *delicate, pleasing*
delgado, *thin, light*

exacto, *exact*

eléctrico, *electric*
entero, *whole, entire*
extraordinario, *extraordinary*
especial, *special*
excelente, *excellent*
extraño, *strange, queer*
espléndido, *splendid*
erróneo, *erroneous, mistaken*
elástico, *elastic*
(del) Este, *eastern*

firme, *firm, stable*
falso, *false*
famoso, *famous*
favorable, *favourable*
fértil, *fertile*
fino, *fine*
fijo, *fixed*
franco, *frank, free*
frecuente, *frequent*
fresco, *fresh*
físico, *physical*
femenino, *feminine*

gran, grande, *big, great, tall*
general, *general*
gris, *grey*

honrado, *honest, honourable*
humilde, *humble*
humano, *human*

inquieto, *uneasy*
igual, *equal*
ilustre, *illustrious*
importante, *important*
ideal, *ideal*
inmediato, *immediate*
inútil, *useless*
inmenso, *immense*
imposible, *impossible*
inclinado, *inclined*

justo, *just, exact*
junto, *joined, united*

liberal, *liberal*
local, *local*

Section 1. ADJECTIVES SIMILAR IN FORM OR USAGE IN SPANISH AND ENGLISH *(contd.)*

largo, *wide, broad, long*

(el) mínimo, *least*
militar, *military*
moderno, *modern*
moral, *moral*
mucho, *much*

negro, *black*
nacional, *national*
nativo, *native*
natural, *natural*
necesario, *necessary*
nuevo, *new*
noble, *noble*
(del) Norte, *northern*
normal, *normal*
numeroso, *numerous*

oriental, *eastern*
occidental, del oeste, *western*
oscuro, *dark, obscure*
ocupado, *occupied, busy*
ordinario, *ordinary*
original, *original*
otro, *other*

polvoroso, *dusty*
pasado, *past*
probable, *probable*
principal, *principal*
próximo, *next*
perfecto, *perfect*
permanente, *permanent*
personal, *personal*
político, *political*
popular, *popular*
posible, *possible*
práctico, *practical*
precioso, *precious, valuable*
privado, *private*
puro, *pure, clean*
rápido, *rapid, fast*
raro, *rare*
reciente, *recent*
regular, *regular*
religioso, *religious*
rico, *rich*

seguro, *secure, certain*
satisfecho, *satisfied*
serio, *serious, grave*
suave, *soft*
sano, *healthy* . **malsano,** *unhealthy*
solo, *alone, only*
singular, *singular*
segundo, *second*
severo, *severe*
silencioso, *silent*
sincero, *sincere*
social, *social*
sólido, *solid*
superior, *superior higher*
salvaje, *savage*
sud, del sur, *southern, south*

tremendo, *tremendous, grand*
tranquilo, *quiet*
terrible, *terrible*

último, *last, final*
único, *unique, only*
universal, *universal*
útil, *useful*

vario, *various, different*
vano, *vain*
violento, *violent*

Section 2. ADJECTIVES DISSIMILAR IN THE TWO LANGUAGES

algún, *some*
aquel, *that one*
atrayente, *attractive*
amargo, *bitter*
azul, *blue*
ambos, *both*
ancho, *broad, wide*
alegre, *merry, lively*
amistoso, *friendly*
agradecido, *grateful*
alto, *tall, high*
abierto, *open*

bajo, *low*
bello, *beautiful*
barato, *cheap*
bobo, *silly, stupid*
buen(o), *good*
bonito, *pretty*

ciego, *blind*
cuidadoso, *careful*
cada, *each*
cariñoso, *affectionate*
cálido, *warm (of food, etc.)*
caro, *costly, dear*
caliente, *hot (general word)*
chico, *small*
cuadrado, *square*
cansado, *tired*
cualquier, *any*
corto, *short*

deleitoso, *delightful*
derecho, *right, straight*
deseoso, *desirous*
dichoso, *happy*
duro, *hard*
disponible, *free, disposable*
dulce, *sweet*
desgraciado, *unfortunate*
digno, *worthy*

enojado, *annoyed, angry*
enfermo, *ill, sick*
ese, *that*
este, *this*
escondido, *hidden*
estrecho, *narrow*

frío, *cold*
fácil, *easy*
fiel, *faithful*
feo, *ugly*
flaco, *weak, feeble*
feliz, *happy*
flojo, *lax, slack, lazy*
fuerte, *strong*

gordo, *fat, plump*
grueso, *thick, bulky, gross*
gastado, *worn-out, spent*
gracioso, *pleasing, funny*

hondo, *deep*
hermoso, *beautiful*
hueco, *hollow, empty*

izquierdo, *left (-hand side)*

joven, *young*
llano, *plain, level, flat*
lleno, *full*
limpio, *clean*
limbre, *free*
lento, *slow, lingering*
loco, *mad, insane*
lindo, *pretty, beautiful*
listo, *ready, apt*
ligero, *light* (not *heavy*)
liso, *plain, flat, even*

mal, malo, *bad*
mejor, *better*
moreno, *brown, swarthy*
mudo, *dumb*
muerto, *dead*
manso, *tame, meek, gentle*
medio, *half*
malsano, *unhealthy*
mismo, *same*

óptimo, *best*
(de) oro, *golden*
ocioso, *idle, lazy*
orgulloso, *proud*

peligroso, *dangerous*
poco, *little, small (quantity)*
primero, *first*
pardo, *drab, grey*
pesado, *heavy*
pequeño, *small (size)*
pequeñito, *very small*
pobre, *poor*
pronto, *ready, quick*
propio, *proper, one's own*
presto, *ready, prepared*
peor, *worse*
(el) peor, *the worst*

querido, *dear, darling, loving*

rojo, *red*
redondo, *round*

sucio, *dirty*
sordo, *deaf*
seco, *dry*
siguiente, *following next*
suelto, *loose*
semejante, *similar*
sencillo, *simple*
soltero, *bachelor, single*
soñoliento, *sleepy, drowsy*
súbito, *sudden*
sabio, *wise, sage*

temprano, *early*
tal, *such*
tanto, *so (much)*
tonto, *idiotic, stupid*
tarde, *late*
todo, *all*
triste, *sad*
tieso, *hard, stiff*

vivo, *living*
viejo, *old*
vacío, *empty*
verde, *green*
verdadero, *true*

INVARIABLE WORDS

1. ADVERBS

acá, *hither*
ahora, *now*
aquí, *here*
allá, allí, ahí, *there, thither*
antes, *before*
aun, *yet, as yet, even*
ayer, *yesterday*
así, *so, thus*
abajo, *down, below*
acaso, *perhaps*
adelante, *forward*
afuera, *outside, abroad*
anoche, *last night*
apenas, *scarcely*
aprisa, *quickly*
arriba, *up, upstairs*
atrás, *backwards*
a la moda, *in fashion, style*
al momento, *instantly*
a más tardar, *at the latest*
a menudo, *often* (**muy—,** *very often*)
a veces, *sometimes*
a tiempo, *in time*
a la derecha, *to the right*
a la izquierda, *to the left*
al rededor, *around*
al por mayor, *wholesale*
al por menor, *retail*
al fiado, *on credit, trust*
algo, *somewhat*
anteayer, *day before yesterday*
alto, *aloud, high*
atrasado, *behindhand, behind*
adelantado, *ahead, in ad-*
bien, *well*
bastante, *enough*
bajo, *under, underneath*

como, *as*
cuando, *when*
con todo, *notwithstanding*
casi, *almost*
claro, *clearly*
cerca, *near*
contra, *against*

de buena gana, *willingly*

INVARIABLE WORDS—ADVERBS (*contd.*)

de mala gana, *unwillingly*
después, *after, afterwards*
donde, *where* (also, **adonde**)
de nuevo, *again, anew*
de vez en cuando, *from time to time*
de noche, *by night*
de día, **by** *day*
dentro, *within*
detrás, *behind*
despacio, *slowly*
demás, *besides, above a certain quantity*
demasiado, *too much*
desde, *since*
durante, *during in the meantime*

entonces, *then*
en seguida, *soon, immediately, at once*
enfrente, *opposite*

en otra parte, *elsewhere*
en todas partes, *everywhere*
en ninguna parte, *nowhere*
encima, *above, over*

fuera, *out, outside* (**de fuera**)

gota a gota, *drop by drop*

hoy, *to-day*
harto, *full, sufficient*

jamás, *never* (stronger than **nunca**)

luego, *soon*
lejos, *far*

mañana, *tomorrow*
más, *more*
menos, *less*

mucho, *much*
muy, *very*
mañana por la mañana, *tomorrow morning*
mal, *badly*
más o menos, *more or less*

ni *nor*
no, *no, not*
nunca, *never*

poco, *little*
poco a poco, *little by little* (*quantity*, *degree*)
pues, *then*
pasado mañana, *day after tomorrow*
por último, *finally*
paso a paso, *step by step*
por aquí, *hereabouts*
por allá, *thereabouts*

quizá, quizás, *perhaps*

raras veces, *seldom*

sí, *yes*
siempre, *always*
sin embargo, *nevertheless*
sólo, *only, alone*
sin duda, *doubtless*

tal vez, *perhaps*
también, *also, likewise*
tan, *so, as*
tanto, *so much*
todavía, *yet, still*
temprano, *early*
tarde, *late*
tampoco, *neither*

últimamente, *lately*

ya, *now, already*

2. PREPOSITIONS

a, *at*
a causa (de), *because of*
a excepción (de), *with the exception of*
a fuerza (de), *by dint of*
a pesar (de), *in spite of*
acerca (de), *about, concerning*
además (de), *in addition to*
alrededor (de), *around*
ante, *before*
antes (de), *before* (*time order*)

bajo, *under*

con, *with*
contra, *against*

conforme (a), *according to*
contrario (a), *contrary to*
correspondiente (a), *corresponding to*
cerca (de), *near, close to*

de, *of*
desde, *from*
durante, *during*
debajo (de), *under, underneath*
delante (de), *before* (*place*)
dentro (de), *within*
después (de), *after* (*time order*)
detrás, *behind* (*time, order*)

en, *in*

entre, *among, between*
excepto, *except*
en cuanto (a), *in regard to*
en frente (de), *in front of*
en vez (de), *instead of*
encima (de), *above, over*

frente (a), *opposite to*
fuera (de), *outside of*

hacia, *towards*
hasta, *until, up to*

junto (a), *close to*

lejos (de), *far from*

mediante, *by means of*

para, *for*
por *for, by*
por causa (de), *on account of, because of*
por razón (de), *by reason of*

respecto (a), *with respect to*

salvo, *save, except*
según, *according to*
sin, *without*
sin embargo (de), *notwithstanding*
sobre, *on*

tras, *after*
tocante, *regarding*

3. CONJUNCTIONS

o, u, *or*
y, e, *and*
pero, **mas**, **sino** } *but*
ni, *nor*
ni . . . siquiera, *not even*
ni . . . ni, *neither . . . nor*
que, *that*
si, *if*
pues, *then, since*
***afín de que**, *in order that*
***a menos que**, *unless*
así que, *so that*
así . . . como, *both . . . and*

***aunque**, ***bien que** } *altho*
apenas . . . cuando, *scarcely . . . when*
***en caso que**, *in case that*
***luego que**, *as soon as*
***mientras que**, *while*
para que, *in order that*
porque, *because*
***de modo que**, ***de manera que** } *so that*
***supuesto que**, *granted that*
no sólo . . . sino, *not only . . . but*

* Take the subjunctive See page 2219

In the above list of words a strict alphabetical order is not observed · this helps in the learning process.

NOTE.—It is often a subtle point of grammar to decide whether a word is adverb, preposition, or conjunction. The learner is advised to be content, for a beginning, with a knowledge of the equivalents given above. Experience will teach him exact usage.

4. INTERROGATIVES

¿ Quién ? *Who ?*
¿ Cuál (es) ? *Which ?*
¿ Cúyo (-a, -os, -as) ? *Whose ?*
¿ Cuánto (-a, -os, -as) ? *How much ? How many ?*
¿ Cuándo ? *When?*

¿ Dónde ? *Where ?*
Adonde ? *Whither ?*
¿ Cómo ? *How ?*
¿ Por qué ? *Why ?*
¿ Qué cosa ?, **¿ Qué ?** } *What ?*

5. INTERJECTIONS

¡ Hola ! *Hello !*
¡ Ole ! *Well done !*
¡ Otra vez ! *Encore ! Again !*
¡ Caramba ! *Heavens !*
¡ Vamos ! *Well, now !*
¡ Vaya !, **¡ Anda !** { *Go on !* (*Tell that to the marines !*)
¡ Bravo ! *Bravo !*
¡ Cuidado ! *Be careful ! Look out !*
¡ Pare ! Alto ! *Stop ! Halt !*
¡ Calla ! *Silence ! Shut up !*
¡ Oiga ! *Listen !*

¡ Ay de mí ! *Alas for me ! etc*
¡ Hombre ! *Very common in all Spanish-speaking countries, and often used to punctuate sentences. Means "My dear fellow," etc. Used alone it may express astonishment.*
¡ Dios !, **¡ Por Dios !**, **¡ Dios mío !** { *Do not mean "My God !" but merely "Good gracious !"*
¡ Adelante ! *Come in !*

6. GREETINGS, etc.

¿ Qué tal ? *Familiar and friendly way of saying* **¿ Cómo está Vd. ?** *How are you ?*
Buenos días, Buenas tardes, Buenas noches. *Good morning, evening, night.*
Hasta luego. *Until we meet*
Hasta la vista. *Au revoir*
Hasta mañana. *Until*

¡ Adiós ! *Good-bye !*
¡ Vaya Vd. con Dios ! *May it go well with you. Farewell !*
¡ Buen viaje ! *May you have a good voyage !*
¡ Buen provecho ! **¡ Buen apetito !** *May it benefit you ! May you have a good appetite !* (*said at mealtimes*)
¡ Salud ! *Good health !*

LESSON 11

Extracts Illustrating Vocabulary and Grammar

(1) MADRID

Hemos recorrido Madrid en las opuestas direcciones que
We surveyed Madrid in directions opposite to those
marcan sus cuatro puntos cardinales, despacio, con paso mesurado
marked by its four cardinal points, slowly, with calculated step
y ojo atento, sin la menor inquietud que pudiera amenguar
and attentive eye, without the least hustle that might diminish
nuestras impresiones. Tuvimos la buena ventura de llegar con
our impressions. We had the good luck to arrive during
unos días sol primaveral que invitaban a las excursiones por
some days of spring sunshine which invited excursions through
los barrios lejanos y por los alrededores. El sol que aquí
outlying districts and suburbs. The sunshine which here
reina déjase sentir con ardores de país tropical y el cielo es
reigns can be felt with (the) ardours of a tropical country and the sky is
tan azul y deslumbrante como los cielos de America. Inquirimos :
as blue and dazzling as that of South America. We inquire
—¿ Siempre hace este sol en Madrid ?
—Is there always sun(shine) like this in Madrid ?
Cuando sale el sol brilla y calienta que da gusto—se nos contesta.
—When the sun comes out it shines and warms so as to give pleasure—we are told
—¿ Y nunca hace frío ? ¿ Nunca soplan vientos huracandados ?
—And it is never cold ? Are there never hurricanes ?
—Rara vez, muy poco—se nos vuelve a contestar.
—Rarely, very little—they answer (again)
No dudamos ya de que nos hallamos en un país de clima
We doubt no more that we are in a country with a benign
benigno, y nos echamos a andar por las aceras de sol en busca de
climate, so we set about walking the sunny paths seeking
sensaciones. Cuando cae el día regresamos al hotel, no sólo para
sensations. When day falls we return to the hotel not only for
reposarnos, sino también para catalogar las sensaciones Luego,
rest, but also to catalogue the sensations. Soon
al tomar la pluma y con el apremio de concretar un juicio, tratamos
on taking the pen and intent upon fixing a judgment, we endeavour
de hacerlo de esta manera : Madrid es una cuidad agradable,
to do it as follows. Madrid is a pleasant city,
bulliciosa, alegre ; alegre y confiada. como se ha dado en llamarla.
lively, cheerful ; cheerful and forward, as it has (so) often been called.
La ciudad de viejo aspecto ha desaparecido para ceder su
The city (in its) old aspect has disappeared to yield place to
lugar a una metrópoli modernísima, con edificios de discutible
a most modern metropolis with buildings of disputable
arquitectura que han sido construidos en un abrir y cerrar de
architecture which have been built in the opening and shutting of
ojos, por obra y gracia del cemento armado. La piedra ha sido
the eyes, by work and grace of reinforced cement Stone has been
relegada. Estamos hoy, indudablemente, en la edad del ladrillo
banished We are, to-day, undoubtedly in the age of brick
y el hormigón. Con todo lo que se pudiera objetar sobre
and concrete. For all that one may be opposed to the
la desigualdad de los estilos arquitectónicos, Madrid realiza
inequality of architectural styles, Madrid represents
el tipo de ciudad municipal—como lo entienden y practican
the type of municipal city—such as is understood and practised by
los alemanes—escrupulosamente limpia y abierta al sol y al aire.
the Germans—scrupulously clean and open to the sun and to the air

This extract is taken with acknowledgements from *España. Meditaciones y Andanzas* by the Argentine writer Ricardo Saenz Hayes (Buenos Aires, 1927.)

NOTE.—In the above and in the next extract, given to illustrate the flexibility and scope of the instrument provided, it will be observed that the difficulties of grammar and vocabulary are few. An occasional reference to a dictionary will nearly always get the student over those for which a solution has not been provided. Occasionally *ideas* rather than words may cause hesitation.

(2) EL DISCURSO DE DON QUIJOTE A LOS CABREROS

DON QUIXOTE'S SPEECH TO THE GOATHERDS

Después que Don Quijote hubo bien satisfecho su estómago, tomó
After (that) Don Quixote had well satisfied his stomach, he took
un puño de bellotas en la mano, y mirándolas atentamente, soltó
a handful of acorns (in his hand), and looking attentively at them, gave
la voz a semejantes razones : " Dichosa edad y siglos dichosos
utterance in this fashion " Happy age and happy centuries (were)
aquellos a quien los antiguos pusieron nombre de dorados ; y no
those upon which the ancients bestowed (the) name of golden ; and not

porque en ellos el oro, que en esta nuestra edad de hierro tanto
because in them gold, which in this iron age of ours is so greatly
se estima, se alcanzase en aquella venturosa sin fatiga alguna,
esteemed, could be obtained in that fortunate (period) without any toil,
sino porque entonces los que en ella vivían, ignoraban estas dos
but because those who lived then did not know these two
palabras de 'tuyo' y 'mío.' Eran en aquella santa edad todas las
words 'mine' and 'thine.' In that blessed age were all
cosas comunes: a nadie le era necesario, para alcanzar su ordinario
things (in) common: to nobody was it necessary, in order to win his daily
sustento, tomar otro trabajo que alzar la mano, y alcanzarle
sustenance, to engage in any work save to extend his hand and take it
de las robustas encinas, que liberalmente les estaban convidando
from the stout oaks, which were liberally inviting
con su dulce y sazonado fruto. Las claras fuentes y corrientes ríos
with their sweet and relishing fruit. The clear fountains and running streams
en magnífica abundancia sabrosas y trasparentes aguas les ofrecían.
offered in magnificent abundance delicious and limpid waters

"**En las quiebras de las peñas y en lo hueco de los árboles**
"In the clefts of (the) rocks and in the hollow of (the) trees
formaban su república las solícitas y discretas abejas, ofreciendo
did the busy and sagacious bees make their republic, offering
a cualquiera mano sin interés alguno la fértil cosecha de su
to every hand without any interest the fertile harvest of their
dulcísimo trabajo. Los valientes alcornoques despedían de sí, sin
sweetest labour. The mighty cork-trees divested themselves, without
otro artificio que el de su cortesía, sus anchas y livianas cortezas,
any other art (but) that of their own courtesy, of their broad light barks,
con que se comenzaron a cubrir las casas sobre rústicas estacas,
with which men began to roof (the) houses (built) on rude stakes,
sustentadas no más que para defensa de las inclemencias del cielo.
supported only as a defence against the inclemency of heaven

"**Todo era paz entonces, todo amistad, todo concordia: aun**
"All was peace then, all friendship, all concord as yet
no se había atrevido la pesada reja del corvo arado a abrir ni
there was no attempt by the heavy ploughshare to (break) open or
visitar las entrañas piadosas de nuestra primera madre, que ella
disturb the tender bowels of our first mother, who
sin ser forzada ofrecía por todas las partes de su fértil y espacioso
without constraint yielded from every part of her fertile and spacious
seno lo que pudiese hartar, sustentar y deleitar a los hijos
bosom all that could fill, sustain and delight the children
que entonces la poseían. Entonces sí que andaban las simples y
who then possessed her. Then (verily) roamed the simple and
hermosas zagalejas de valle en valle y de otero en otero, en trenza
beautiful shepherdesses from vale to vale and hill to hill, tresses flowing
y en cabello, sin más vestidos de aquellos que eran menester para
and braided (and), with no other garments but those needful to
cubrir honestamente lo que la honestidad quiere y ha querido
cover modestly what modesty requires and has required
siempre que se cubra; y no eran sus adornos de los que ahora
always to be covered, nor were their ornaments like those now
se usan, a quien la púrpura de Tiro y la por tantos modos martirizada
used, which (the) purple of Tyre and (the) much tortured
seda encarecen, sino de algunas hojas de verdes lampazos
silk set off, but (only) a few green dock leaves
y yedra entretejidas, con lo que quizá iban tan pomposas y compuestas
and ivy intertwined, wherewith possibly they strutted as bravely and composed
como van ahora nuestras cortesanas con las raras y peregrinas
as do now our courtesans with the rare and far-fetched
invenciones que la curiosidad ociosa les ha mostrado.
artifices which idle curiosity has taught them

"**Entonces se decoraban los concetos amorosos del alma simple y**
"Then were clothed the amorous conceits of the soul simply and
sencillamente del mismo modo y manera que ella los concebía, sin
innocently in the same mode and manner as they were conceived, nor
buscar artificioso rodeo de palabras para encarecerlos. No había
sought (they) by artificial subterfuge of words to enhance them. There was no
la fraude, el engaño ni la malicia mezclándose con la verdad y llaneza.
fraud, or deceit, or malice mingled with truth and straightforwardness.
La justicia se estaba en sus propios términos, sin que la osasen
Justice was kept within her own bounds, nor dared to
turbar ni ofender los del favor y los del interés, que tanto
disturb or assail her either favour or interest, which so greatly
ahora la menoscaban, turban y persiguen. La ley del encaje aun
now impair, pervert, and importune her. Arbitrary law had as yet
no se había sentado en el entendimiento del juez, porque entonces
not possessed the understanding of the judge, for then
no había qué juzgar ni quién fuese juzgado. Las doncellas y la
there was nothing and nobody to be judged. Maidens and
honestidad andaban, como tengo dicho por donde quiera, solas y
modesty wandered, as I have said, where they willed, alone and
señeras, sin temor que la ajena desenvoltura y lascivo intento
unattended, without fear that improper gesture and lewd intent